This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

oc 1816 . 10.3

HARVARD
COLLEGE
LIBRARY

February 2. 1720-1.

At a Meeting of the *ROYAL SOCIETY*,

Sir ISAAC NEWTON, Preſident, *in the Chair*,

Mr. JONES preſented a Scheme and Specimen of an Abridgment of the PHILOSOPHICAL TRANSACTIONS, from the Year 1700 to the Year 1720. This Deſign was approved of by the SOCIETY, and he was deſired to proceed therein.

Edm. Halley, Secr. Reg. Soc.

Octob. 27. 1721.

IMPRIMATUR *Epitome* Tranſactionum Philoſophicarum, *ab Anno* 1700 *ad Annum* 1720, *a D.* Hen. Jones *compoſita.*

ISAAC NEWTON, *Reg. Soc. Præſes.*

THE
PHILOSOPHICAL TRANSACTIONS
(*From the Year* 1700, *to the Year* 1720.)

ABRIDG'D,

AND

Diſpos'd under GENERAL HEADS.

In Two VOLUMES.

By *HENRY JONES*, M. A. and
Fellow of *King's College* in *CAMBRIDGE*.

VOL. IV. Containing

Part I. The MATHEMATICAL Papers.
Part II. The PHYSIOLOGICAL Papers.

The THIRD EDITION Corrected.
In which the *LATIN* PAPERS are now firſt tranſlated into *ENGLISH*.

LONDON:
Printed for W. INNYS, R. WARE, J. and P. KNAPTON, D. BROWNE, T. LONGMAN, C. HITCH, J. HODGES, S. AUSTEN, A. MILLAR, J. and J. RIVINGTON, and J. WARD.
M.DCC.XLIX.

LSoc1816.10.3

TO THE
Right Honourable
THOMAS
Earl of MACCLESFIELD,
Lord High CHANCELLOR
OF
GREAT BRITAIN, &c.

My LORD,

AS the conſiderable Improvements, which Learning has receiv'd, are chiefly owing to the favourable Encouragement and propitious Influence of the Great; So amongſt the many Patrons of the Age there is no one, who has ſhew'd more Encouragement to it than Your Lordſhip, or who is happy in a greater Share of it.

To Your Lordſhip therefore, as the worthieſt Patron, I moſt humbly offer theſe Diſcourſes of the greateſt Authors; which, if they have not ſuffer'd in paſſing through my Hands, are not only highly deſerving of your Acceptance, but ought more particularly in Honour to be inſcrib'd to Your Lordſhip's Name. For to whom could theſe Volumes be ſo properly Dedicated, as to one, who is a perfect Maſter of the Subjects here treated of? Who, like his great Predeceſſor the Lord Chancellor BACON, has taken in the wide Compaſs of Phyſical, as well as Civil Knowledge; and is throughly acquainted with the Laws of Nature, as well as thoſe of the Land? It was His Honour to lay, in ſome Meaſure, the Foundations of thoſe Improvements, which Philoſophy has ſince receiv'd; and it is the peculiar Honour and Advantage of that Philoſophy, to have fallen under Your Lordſhip's Protection in this its maturer State, in an Age abounding with uſeful Inventions and great Diſcoveries: Happy are thoſe Sciences in ſuch a Patron; they muſt certainly continue to flouriſh, when Your Lordſhip does not only encourage them by Your Liberality, but promote them by the Authority of Your own Example.

It is Matter of Surprize, my Lord, that one, whoſe whole Life has been employ'd in the active Part of the World, and in the Buſineſs of a Profeſſion very difficult and laborious, ſhould have any Inclination or Leiſure for thoſe other Parts of

Learning, which your Lordſhip is by all allowed to poſſeſs in a very extraordinary Degree. Who, though you have receiv'd many public Addreſſes of this kind from eminent Authors, yet you have been able (ſuch are Your own natural Parts, and ſuch are Your Improvements of them) to equal thoſe Performances You have condeſcended to patronize. In the Study of Divinity, my Lord, You may well be ſaid, to be inferiour to no one; the late Dr. HICKES has long ſince told the World, that You are a Perſon, "Who to his great Underſtanding "in our Common and Statute Laws, and in the "*Engliſh* Conſtitution before and ſince the Con-"queſt, has added ſuch a Knowledge of all the "moſt uſeful Parts of Divinity, that it is not eaſy "to determine, whether he is better ſkill'd in Hu-"man or Divine Laws." And I may add, who to his great Acquiſitions in the more learned Studies has join'd no leſs Attainments in the politer Arts; whoſe own Speeches, on a very memorable Occaſion, will tranſmit his Character, as a conſummate Orator, to the lateſt Poſterity: Compoſitions applauded and admired by all; and, what is the trueſt Teſt of Merit, commended by thoſe, who diſlik'd the Subject of them.

Theſe Talents ſo various, theſe Qualifications ſo uncommon, have recommended Your Lordſhip to that High Office, which you now adorn: Others have ſtruggled with great Competitors, and contending Equals in the Paths of Ambition; but in Juſtice to your Lordſhip it is to be remember'd, that

You were ſollicited and importun'd to accept the greateſt Truſt in the Nation.

But I muſt not preſume to detain Your Lordſhip any longer, much leſs can I pretend to do Juſtice to Your Character: And as, in preſenting You with theſe Authors, I intend a Piece of great Reſpect to Your Lordſhip; ſo I muſt eſteem it a very great Honour done to me, that any Thing, in which I have had the ſmalleſt Share, can have the Favour of Your Lordſhip's Name, and obtain the Patronage of ſo good a Judge. I am,

My LORD,

Your Lordſhip's moſt Obedient

and moſt humble Servant,

Henry Jones.

THE CONTENTS.

Vol. IV. Part I.

The MATHEMATICAL *Papers.*

CHAP. I.

GEOMETRY, ARITHMETIC, ALGEBRA, LOGARITHMOTECHNY.

I. *THE Proportion of Mathematical* Points *to each other, by the Hon.* Fr. Robartes, *Eſq;* Page 1

II. *Some Properties of* Conic *Sections deduc'd from the Nature of* Focus's, *by Mr.* Abr. de Moivre 3

III. *Tangents to* Curves, *deduced from the Doctrine of the* Maxima *and* Minima, *by Mr.* H. Ditton 7

IV. *A Method of* Squaring *ſome kinds of* Curves, *or of reducing them to more ſimple ones, by Mr.* Abr. de Moivre 15

V. *The* Quadrature *of a* Curve *of the* third *Order, communicated by Mr.* Abr. de Moivre 25

VI. *A Specimen of a general Method to determine the* Quadratures *of Figures, by Mr.* J. Craig 26

VII. *A Problem of finding other* Curves *equal in Length to any given* Geometrical *Curve, ſolved by Mr.* J. Craig 35

VIII. *The Conſtruction and Properties of a new* Quadratrix *to the* Hyperbola, *by Mr.* Perks 37

IX. *Of the Length of* Curve *Lines, by Mr.* J. Craig 44

X. *A general Solution of a Problem* (*concerning* Curves) *propoſed in the* Leipſic *Acts,* Oct. 1698, *by*——— 45

XI. *Mr.* Leibnitz's *Problem* (*concerning Curves*) *ſolved by Dr.* B. Taylor 46

XII. *The Conſtruction and Meaſure of* Curves, *by Mr.* C. Maclaurin 51

XIII. *A Method of deſcribing all kinds of* Curves, *by only giving the Angles and right Lines, by Mr.* C. Maclaurin 57

XIV. *The Doctrine of* Combinations, *and* Alternations *improved and completed, by Major* E. Thornycroft 60

XV. *An univerſal Solution* (viz. *Analytical, Geometrical and Mechanical*) *of* Cubic *and* Biquadratic Equations, *by Mr.* John Colſon 66

XVI. *An analytical Solution of* Equations *of the* 3d, 5th, 7th, 9th, *&c. Powers, by Mr.* Abr. de Moivre 77

XVII. 1. *The Method of* Approximating (*in extracting the* Roots *of* Equations *in Numbers*) *improved, by Dr.* B. Taylor 80

2. *A General* Series *for expreſſing the* Root *of any* Quadratic Equation, *by the* ſame 86

3. *A new Method of computing* Logarithms, *by the* ſame 87

XVIII. 1. *A Treatiſe of* infinite *Series's, the* firſt *Part, by* P. R. de Monmort 90

2. *An Appendix on the ſame Subject, by Dr.* B. Taylor 130

XIX. *The* Newtonian *differential Method illuſtrated, by Mr.* J. Sterling 141

XX. *A general Method of making* Logarithms, *by Mr.* J. Craig 156

XXI. *A new Method of making* Logarithms, *communicated by Mr.* J. Long 160

XXII. *A Letter from Monſieur* l'Abbé Conti, *to Mr.* Leibnitz (*concerning the Invention of the Method of* Fluxions) *with Mr.* Leibnitz's *Anſwer* 162

XXIII. *Dr.* Taylor's *Apology againſt Mr.* J. Bernoulli 165

XXIV. *A Vindication of Mr.* J. Gregory, *by Dr.* D. Gregory 168

XXV. *A Paper omitted* 170

XXVI. *Accounts of Books,* &c. *omitted* *ibid.*

The CONTENTS.

CHAP. II.

OPTICS.

I. SIR Iſaac Newton's *Experiments on* Light *and* Colours *repeated, by Dr.* J. T. Deſaguliers 173
II. *An Experiment to confirm Sir* Iſaac Newton's *Doctrine of the* Refrangibility *of the Rays of Light, by the* ſame 181
III. *An univerſal* Sphærico-Catoptric *Theorem, by Mr.* H. Ditton 184
IV. *A way for* Myopes *to uſe* Teleſcopes *without* Eye-Glaſſes, *&c. communicated by Dr.* J. T. Deſaguliers 188
V. *Experiments upon* Metals *with the* D. *of* Orleans's *Burning-Glaſs, by Monſ.* Geoffroy 190
VI. *Experiments with Monſieur* Villette's *Burning-Glaſs, by Dr.* J. Harris, *and Dr.* J. T. Deſaguliers 198
VII. *A Pocket* Microſcope, *by Mr.* J. Wilſon 199
VIII. *The Manner of making* Microſcopes, *by Dr.* A. Adams 203
IX. *An Account of a Book omitted* 205

CHAP. III.

ASTRONOMY.

I. OF Caſſini's *Orbit of* Planets, *by Dr.* Gregory 206
II. *The* Newtonian *Solution of* Kepler's *Problem demonſtrated, by Dr.* John Keil 208
III. *The* Parallax *of the* Sun *to be found, by ſeeing* Venus *between the* Sun *and the* Earth, *by Dr.* E. Halley 214
IV. *Of the* Maxima *and* Minima *occurring in the* Motions *of the Heavenly Bodies, by Mr.* Abr. de Moivre 220
V. *Of a new Star in* Collo Cygni, *by Mr.* G. Kirch 222
VI. *A Hiſtory of the new Stars for the laſt* 150 *Years, by Dr.* E. Halley 224
VII. *Lucid Spots or* Nebulæ *amongſt the fixt Stars, by* ——— 225
VIII. *Of the Change of* Latitude *of ſome of the fixt Stars, by Dr.* E. Halley 227
IX. *Of Mock-ſuns and circular Arches, by Dr.* E. Halley 228
X. 1. Spots *obſerved in the* Sun, *in* June 1703, *by Mr.* S. Gray 229
  2.—*on the ſame, by Mr.* W. Derham 230
  3.—*on the ſame,* 1704, *by Capt.* Stannyan 232
  4.—*on the ſame, from* 1703 *to* 1708, *by Mr.* W. Derham 235
  5.—*on the ſame, from* 1708 *to* 1711, *by Mr.* W. Derham 240
  ———*Mr.* Crabtrie's *Opinion of theſe Spots* 241
XI. *An* Eclipſe *of the* Sun, June 12. 1694, *in* New-England, *by Mr.* T. Brattle 247
XII. *An* Eclipſe *of the Sun,* Nov. 23. 1703, *in* New-England, *by the* ſame 249
XIII. 1. *An* Eclipſe *of the Sun,* May 1. 1706, *obſerved at* Greenwich, *by Mr.* J. Flamſtead 249
  2.—*at* Canterbury, *by Mr.* S. Gray 250
  3.—*at* Horton *in* Yorkſhire, *by Mr.* Abr. Sharp 251
  4.—Bern *in* Switzerland, *by Capt.* Stannyan *Ib.*
  5.—*at* Geneva, *by Mr.* J. C. Facio 252
  6.—*at* Marſeilles, *by Monſieur* Chazelles *and Father* Laval 253
  7.—*at* Zurich, *by Dr.* J. J. Scheuchzer 254
XIV. *An* Eclipſe *of the Sun,* Sept. 3. 1708. *at* Upminſter, *by Mr.* W. Derham 255
XV. 1. *Obſervations on the* Total Eclipſe *of the Sun,* April 22. 1715. *at* London, *by Dr.* E. Halley. *ibid.*
  2.—*Accounts of the ſame from abroad* 266
XVI. *An* Eclipſe *of the Sun,* Feb. 19. 1718. *at* Nurenburgh, *by M.* Wurtzelbau, *and at* Berlin *by Mr.* G. Kirch 268
XVII. *An* Eclipſe *of the Moon at* Cambridge *in* New-England, Feb. 11. 1700, *by Mr.* T. Brattle *ibid.*
XVIII. 1. *An* Eclipſe *of the Moon,* Dec. 12. 1703. *at* Cambridge *in* New-England, *by Mr.* T. Brattle 269
  2.—*on the ſame at* London, *by Mr.* J. Hodgſon, *with Remarks* 271

XIX. *An*

XIX. *An* Eclipſe *of the Moon*, April 5. 1707. *at* Boſton *in* New-England, *by Mr.* T. Brattle *ibid.*

XX. —— *on the ſame at* Zurich, *by the two Doctors* Scheuchzer's 272

XXI. *An* Eclipſe *of the Moon*, Sept. 18. 1708. *at* Upminſter, *by Mr.* W. Derham 275

XXII. *The Account of the Moon's* Eclipſe *at* Streatham, Feb. 2. 1709-10. *compared with the Calculation, by Mr.* H. Creſſener *ibid.*

XXIII. *An* Eclipſe *of the Moon*, Jan. 12. 1711-12. *at* Upminſter, *by Mr.* W. Derham 277

XXIV. *An* Eclipſe *of the Moon*, Oct. 30. 1715. *at* Wanſtead, *by Mr.* J. Pound 278

XXV. Aſtronomical *Obſervations for* 1711. *and* 1712. *at* Greenwich, *by Mr.* J. Flamſtead 281

XXVI. — *the ſame for* 1713. *by the* ſame 291

XXVII. *Obſervations of the* Occultations *of the* fixt Stars *by the* Moon, *uſeful for finding the* Longitude, *with a Catalogue of the Places of the* Hyades, &c. *by* —— 298

XXVIII. *An Account of the Cauſe of* Venus *being ſeen in the* Day-time, *for ſeveral Days together, by Dr.* E. Halley 300

XXIX. *The* Occultation *of a* Star *by the* Moon, *and an Eclipſe of the* Moon *following in* Nov. 21. 1713. *by Mr.* F. Blanchini 302

XXX. *The* Occultation *of* Jupiter *by the* Moon, July 14. *in the Morning*, 1715. *at* Wanſtead, *by Mr.* J. Pound 303

XXXI. *The* Occultation *of a fixt Star in* Gemini *by* Jupiter, Jan. 11. 1717. 304

—*and a Tranſit of* Mars *below the Northern Star in the Forehead of* Scorpio, Feb. 5. 1717 305

XXXII. *Emerſions of the firſt Satellite of* Jupiter, *in* 1713. *at* Rome, *by Mr.* F. Blanchini 306

XXXIII. *A Tranſit of* Jupiter's *fourth* Satellite *over the Disk of the Planet*, Feb. 1719. *Communicated by Mr.* J. Pound 307

XXXIV. Tables *for computing the Eclipſes of* Jupiter's *firſt Satellite, by Mr.* J. Pound 308

XXXV. *Obſervations on ſome of the primary* Planets, *and the* Occultation *of a fixt Star, by* Jupiter, *by the* ſame. 318

XXXVI. *A* Rectification *of the Motions of the five Satellites of* Saturn; *with Obſervations, by the* ſame 320

XXXVII. Caſſini's *Tables of the Motions of* Saturn's *Satellites corrected* 323

XXXVIII. *A Collection of* Aſtronomical *Obſervations, for* 1717, 1718. *by* —— 329

—*of an* Eclipſe *of the Moon*, Aug. 29. 1718. *at* Wanſtead, *by Mr.* J. Pound 334

XXXIX. *A Collection of* Aſtronomical *Obſervations, for* 1719. *by* —— 336

XL. *Obſervations on the Comet*, 1664. *at* Rome, *by Mr.* J. Ray 339

XLI. — *on a Comet*, 1680. *in* Saxony, *by M.* G. Kirch 340

XLII. — *a Comet*, 1718. *at* Berlin, *by the* ſame 342

XLIII. *A ſmall* Teleſcopical *Comet*, June 10. 1717. *by Dr.* E. Halley 344

XLIV. *Papers omitted* 345

XLV. *An Account of a Book omitted* *ibid.*

CHAP. IV.

MECHANICS, ACOUSTICS.

I. 1. To *find a* Solid *of the leaſt* Reſiſtance, *by Mr.* J. Craig 346

2. *On the ſame, by Mr.* N. Facio 348

II. *To find a Line of the* Quickeſt Deſcent, *by Mr.* J. Craig 351

III. *To find the* Curve *which a* falling *Body would deſcribe*, &c. *by Mr.* J. Machin 351

IV. *The Laws of* Attraction, &c. *by Dr.* John Keill 353

V. *The Laws of the* Centripetal *Force, by the* ſame 359

VI. *Of the* Inverſe Problem *of the Laws of the* Centripetal *Force, with Remarks on* Bernoulli, *by the* ſame 367

VII. *To find the Centre of* Oſcillation, *by Dr.* B. Taylor 384

VIII. *Of the Motion of a* Stretcht String, *by the* ſame 391

IX. *The Invention of making* Clocks *to keep time with the* Sun's *Apparent* Motion *aſſerted, by Mr.* J. Williamſon 394

X. *Experiments and Obſervations on the Motion of* Sound, *by Mr.* W. Derham 396

XI. *Of the Nature and* Properties *of* Sound, *by* G. Grandus 414

XII. *A Paper omitted* 423

The CONTENTS.

CHAP. V.

HYDROSTATICS, HYDRAULICS.

I. OF *the Aſcent of* Water *between two* Glaſs Planes, *by Dr*. B. Taylor 423
II. *The Cauſe of the* Aſcent *and* Suſpenſion *of Water in* Capillary *Tubes, by Dr*. J. Jurin *ibid.*
III. *The Action of* Glaſs Tubes *upon Water and Quickſilver, by the* ſame 428
IV. *Of the Motion of running Waters, by the* ſame 436
V. *The* Heſſian *Bellows improv'd, by Mr*. D. Papin 447
VI. *An Account of a Book omitted* 448

CHAP. VI.

GEOGRAPHY, NAVIGATION.

I. A *Demonſtration of the Number of* Acres, *in* England, *by Dr*. N. Grew 449
II. *The Difference of* Longitude *between* London *and* Cambridge, *in* New-England, *by Mr*. J. Hodgſon 451
III. *The* Longitude *of the Cape of* Good Hope, *&c. by Dr*. E. Halley *ibid.*
IV. *Of the* Variation *at* Paraïba, *and the* Longitude *of the* Magellan *Straights*, &c. *by the* ſame 453
V. *The* Variation *in* 1706. *in the* Atlantic, *and* Æthiopic *Oceans, by Mr*. J. Maxwell 456
VI. *The Nautical* Meridian Line *mechanically divided*, &c. *by Mr*. J. Perks 456
VII. 1. *A new way of drawing a* Meridian Line, *by Mr*. S. Gray 461
2 —*on the ſame, by the* ſame 462
VIII. *An Inſtrument for finding the* Meridian, *by Mr*. W. Derham 464
IX. *Of a* Meridian Line *drawn through* France, *&c. communicated by Monſ*. Geoffroy 468
X. *A Paper omitted* 469

CHAP. VII.

MUSIC.

I. THE *Theory of* Muſic *reduced to* Arithmetical *and* Geometrical *Proportions, by Mr*. T. Salmon. 469
II. *Of the Antient* Greek *and* Roman *Lyre; and a Paſſage in* Horace *explained thereby, by Dr*. T. Molyneux. 474

THE CONTENTS.

VOL. IV. Part II.

The PHYSIOLOGICAL *Papers.*

CHAP. I.

PHYSIOLOGY, METEOROLOGY, PNEUMATICS.

I. *A Scale of the Degrees of* Heat, *by*—— Page 1
II. *An Account of Dr.* Hook's *Marine* Barometer, *by Dr.* E. Halley 4
III. *A new* Baroſcope, *by Mr.* Caſwell 6
IV. *A new* Thermometer, *by Monſieur* Geoffroy 10
V. *The Cauſe of the* Variation *of the* Barometer, *&c. by Dr.* J. T. Deſaguliers *ibid.*
VI. *Experiments made with the* Barometer *in* Switzerland, *by Dr.* J. J. Scheuchzer 16
VII. *Obſervations on the* Weather, *&c. in a Voyage to* China, 1700. *by Mr.* J. Cunningham 18
VIII. *A Regiſter of the* Weather, 1700 *at* Chuſan *in* China, *by the* ſame 27
IX. *A Regiſter of the* Weather *for* 1692 *in* Eſſex, *by Mr.* J. Locke 48
X. 1. *Obſervations on the* Weather, Rain, Winds, *&c. for* 1699, 1700, 1701, 1702. *by Mr.* W. Derham 62
  2. — *on the ſame for* 1703, 1704. *by the* ſame 67
  3.—*on the ſame for* 1705, *by the* ſame 74
XI. *Tables of the* Barometrical *Altitudes,* &c. *for* 1708. *at* Zurich *in* Switzerland, *by Dr.* Scheuchzer; *and of the Rain at* Piſa *in* Italy *by Dr.* Tilli, Zurich, *by Dr.* Scheuchzer, *and at* Upminſter, *for* 1707, 1708. *with Remarks, by Mr.* W. Derham 77
XII. *The Quantity of* Rain *at* Upminſter *for* 18 *Years, compared with the Rain at* Paris, *by Mr.* W. Derham 100
XIII. *A Storm of Rain at* Denbigh *in* Wales, *by*—— 101
XIV. 1. *A* Water-Spout *obſerved in the* Downs, *by Mr.* P. Gordon 103
  2. Spouts *in the* Mediterranean, *by Dr.* A. Stuart *ibid.*
  3. *A* Spout *in* Yorkſhire, *by Mr.* Abr. de la Pryme 106
  4.— *Another by the* ſame 107
  5. *Another in* Lancaſhire, *by Dr.* R. Richardſon 108
XV. *Of a Storm of* Hail *in* Yorkſhire, *by Mr.* R. Thoreſby 109
XVI. 1. *Obſervations on the great* Storm, Nov. 26 1703. *by Mr.* W. Derham *ibid.*
  2.—*on the ſame in* Suſſex, *by Mr.* J. Fuller 112
  3.—*on the ſame by Mr.* Leeuwenhoek *ibid.*
XVII. *The Hiſtory of the great* Froſt, 1708. *by Mr.* W. Derham 113
XVIII. 1. *Strange Effects of* Thunder *and* Lightning *in* Ireland, *communicated by Mr.* S. Molyneux 126
  2. Thunder *and* Lightning *at* Ipſwich, *by Mr.* O. Bridgman 128
  3.—*The Effects of the ſame at* Colcheſter, *by Mr.* J. Nelſon 129
  4. *Thunder, and Lightning, and Rain in* Yorkſhire, *by Mr.* R. Thoreſby 130
  5.—*in* Yorkſhire, *by the* ſame 131
  6.—*in* Devonſhire, *by Mr.* J. Chamberlayne *ibid.*

XIX. *A*

The CONTENTS.

XIX. *A Fiery Meteor*, &c. *in* Jamaica, *by Mr.* H. Barham 131
XX. *A* Lunar *Rainbow in* Derbyſhire, *communicated by Mr.* R. Thoresby 132
XXI. *A* Glade *of* Light *in the Heavens*, 1706, *by Mr.* W. Derham 133
XXII. *A* Pyramidal *Appearance in the Heavens*, 1707, *by the* ſame *ibid.*
XXIII. *A Meteor in* Yorkſhire, *by Mr.* R. Thoreſby 134
XXIV. *A ſtrange Meteor, or* Aurora Borealis, *in* Ireland, 1707, *by Mr.* Neve *ibid.*
2.—*Another* 1706, *communicated by Mr.* W. Derham 135
XXV. *An Account of ſeveral extraordinary* Meteors, *by Dr.* E. Halley *ibid.*
XXVI. 1. *An Account of* Lights, *&c. ſeen in the Air*, March 6, 1715-16, *by Dr.* E. Halley 139
2.—*of the ſame ſeen on the Ocean* 151
3.—*a Return of the ſame* 152
XXVII. 1. *Two* Northern Aurora'*s in* Kent, 1717, *by Mr.* E. Barrel 153
2.—*one of them ſeen at* London, *by* M. Folkes *Eſq;* 154
XXVIII. *An Account of an extraordinary Meteor*, March 19, 1718-19, *by Dr.* E. Halley 156
XXIX. 1. *Of an extraordinary* Aurora Borealis, Nov. 10, 1719, *by Dr.* E. Halley 163
2.—*of the ſame in* Devonſhire, *by* W. Maunder 164
3.—*of the ſame at* Dublin, *by* —— 165
XXX. *An* Aurora Borealis, Dec. 11. 1719 *in* Surrey, *by Mr.* T. Hearne 167
XXXI. *Of* Northern Aurora'*s ſeen abroad, by Dr.* T. Robinſon 168
XXXII. *Experiments on the Motion of* Pendulums *in* Vacuo, *by Mr.* W. Derham *ibid.*
XXXIII. 1. Gunpowder *fir'd in* Vacuo, *by Mr.* F. Hawkſbee *ibid.*
2.— *the Quality of the* Air *produc'd by* Gunpowder, *by the* ſame 172
XXXIV. *The Deſcent of* Malt-Duſt *in* Vacuo, *by the* ſame 173
XXXV. *An Experiment to prove an* Interſperſed Vacuum, *by Dr.* J. T. Deſaguliers *ibid.*
XXXVI. 1. *Experiments to find how much the* Reſiſtance *of the* Air *retards* Falling Bodies, *by the* ſame 175
—*Some farther Experiments on the ſame Subject, by the* ſame 178
XXXVII. *Papers of Mr.* Hawkſbee'*s omitted* 180

CHAP. II.

HYDROLOGY.

I. *Of the Lake* Vetter, *in* Sweden, *by Dr.* U. Hearne 183
II. *A New Contrivance for* Diving, *by Dr.* E. Halley 188
III. *Of an Eruption of Waters in* Yorkſhire, *by Mr.* R. Thoreſby 192
IV. *Of Inundations in* Ireland, *by Mr.* Neve 193
V. *Of the Lake* Lough-Neagh *in* Ireland, *by Mr.* F. Neville *ibid.*
VI. *The Eruption of a Burning-Spring in* Shropſhire, *by Mr.* R. Hopton 195
VII. *Of a* Chalybeat *Water at* Canterbury, *by Dr.* Sc. des Moulins 197
VIII. *An Examen of the* Spaw *Waters, by Dr.* F. Slare 198
IX. *Of the Nature and Vertues of the* Pyrmont *Waters, by the* ſame 201
X. *Accounts of Books omitted* 204

The CONTENTS.

CHAP. III.

MINERALOGY.

I. THE *way of* Colouring *Marble, by* —— 205
II. *A Quarry of Marble in* Ireland, *by Mr.* F. Neville 206
III. *A* Colliery *blown up near* Newcaſtle, *communicated by Dr.* A. Charlett *ibid.*
IV. 1. *An* Eruption *of Mount* Veſuvius *in* 1707. *by the Hon.* J. Valetta 207
2.—*other* Eruptions *in* 1717. *by Mr.* E. Berkeley 209
V. *An* Earthquake *in the* North *of* England, 1703. *by Mr.* R. Thoreſby 210
VI. 1. *Of* Subterraneous Trees *in* Hatfield-Chace, *by Mr.* Abr. de la Pryme 212
2.—*on the ſame Subject, by the* ſame 218
VII. Subterraneous Trees *at* Dagenham *in* Eſſex, *by Mr.* W. Derham 219
VIII. 1. *Strange* Bones *dug up near* Canterbury —*And of an* Iſthmus *between* Dover *and* Calais, *by Mr.* W. Somner 222
2.—*on the ſame, by Dr.* J. Wallis 227
3.—*on the ſame Subject, by the* ſame 233
4.—*on the ſame*——*by the* ſame *ibid.*
IX. 1. *An Account of* large Teeth *dug up in* Ireland, *by Mr.* F. Neville 236
2.—*Remarks on them, by Dr.* T. Molyneux 237
3.—*Further Remarks, by Dr.* E. Halley 244
X. *An Account of* large Bones *found near* Colcheſter, *by Mr.* J. Luffkin 245
XI. 1. Coins, *&c. found under* Ground *in* Lincolnſhire, *by*—— 246
2.—*A Remark, by Mr.* R. Thoreſby 248
XII. *Of an uncommon* Sinking *of the* Earth *in* Kent, *by Mr.* J. Sachette *ibid.*
XIII. *Part of a* Hill Sinking *down in* Ireland, *communicated by the Biſhop of* Clogher 250
XIV. *Of the* ſunk Iſland *in the* Humber *recover'd from the* Sea; *communicated by M.* J. Chamberlayne 251
XV. *Of the* Sinking *of three* Oaks *into the* Ground *in* Norfolk, *communicated by Mr.* P. le Neve 252
XVI. 1. *Of the* Moſſes, *&c. in* Scotland, *by the Earl* Cromerty 253
2.—*On the ſame, by Sir* Hans Sloane 256
XVII *Of the* Strata *in* Coal Mines, *by* J. Strachey, *Eſq;* 260
XVIII. 1. *Of the* Foſſils, *&c. of* Reculver *Cliff, by Mr.* S. Gray 263
2.—*A Remark, by Sir* Hans Sloane *ibid.*
XIX. 1. *Some Remarks on* Foſſils, *by Mr.* E. Lhuyd 264
2.—*Of* Harwich *Cliff, and its Foſſils, by Mr.* S. Dale *ibid.*
XX. *An Account of* Land *and* River-Shells *found under* Ground, *by Mr.* J. Morton 270
XXI. *An Account of the* Skeleton *of an Animal impreſs'd in* Stone, *by Dr.* W. Stukeley 272
XXII. *Of* Cryſtal, Iron *and* Copper Ore, *by Mr.* R. Thoreſby 274
XXIII. *Of the* Luminous *Qualities and* Electricity *of Amber, Diamonds, and Gum-Lac, by Dr.* Wall 275
XXIV. *A Treatiſe on* Amber, *by Father* G. J. Camelli 279
XXV. 1. *Of the* Lapis Aſbeſtus, *and the Way of making the incombuſtible Cloth, by* J. Campani 282
2.—Aſbeſtus *in* Scotland, *by Mr.* J. Wilſon 283
3.—*the ſame, by Mr.* P. Blair 285
XXVI. *Papers omitted* *ibid.*
XXVII. *Accounts of Books omitted* 286

CHAP.

The CONTENTS.

CHAP. IV.

MAGNETICKS.

I. OF *the Invention and Improvements of the Mariner's Compaſs, by Dr.* J. Wallis 286

II. 1. Magnetical *Experiments and Obſervations, by Mr.* W. Derham 290

2. *Further Obſervations, by the ſame* 291

III. 1. *Experiments concerning the* Proportion *of the* Power *of the* Loadſtone *at* Different Diſtances, *by Mr.* F. Hawkſbee 295

2. *Another Experiment on the ſame, by Dr.* B. Taylor 297

CHAP. V.

AGRICULTURE, BOTANY.

I. OF *the* Manuring *Lands by* Sea-Shells *in* Ireland, *by the Lord Archbiſhop of* Dublin. 298

II. *Of the* Manuring *Lands by* Sea-Sand *in* Devonſhire, *by Dr.* A. Bury 301

III. *Obſervations relating to the Motion of the* Sap *in Vegetables, by Mr.* R. Bradley 302

IV. *Of the Parts and Uſe of the* Flower *in Plants, by Mr.* S. Moreland 305

V. *Of the quick Propagation of* Moldineſs *in a* Melon, *by Mr.* R. Bradley 308

VI. *Of the Huſbandry of* Canary-Seed, *by Mr.* E. Teniſon 309

VII. *Experiments on* Vegetation, *by Mr.* Abr. de la Pryme 310

VIII. *The great and ſpeedy* Vegetation *of* Turnips, *communicated by* J. T. Deſaguliers 311

IX. *Of the Culture of* Tobacco *in* Ceylan, *by Mr.* Strachan 312

X. *Of a* Tartarian *Plant called* Gin-ſeng *or* Ninzin, *by Father* Jartoux 314

XI. Araliaſtrum, *a new Genus of Plants (of which* Gin-ſeng *is a Species) communicated by Monſieur* Vailiant *to Dr.* W. Sherard 319

XII. *Of a new Plant from* Braſil *called* Iquetaia, *by Monſieur* Marchand 321

XIII. *Of the* Atmella, *and its Lithontriptic Vertue, by Dr.* P. Hotton 322

XIV. *Of the* Jeſuits Bark, *by Dr.* W. Oliver 323

XV. *Of a new Kind of* Walnut-Tree, *by Monſieur* Reneaume *ibid.*

XVI. *Papers omitted* 325

XVII. *Accounts of Books omitted* *ibid.*

THE
Philoſophical Tranſactions
ABRIDG'D.

PART I.

Containing the

Mathematical PAPERS.

CHAP. I.

Geometry, *Arithmetic*, *Algebra*, *Logarithmotechny*.

The Proportion *of Mathematical* Points *to each other, by the Hon.* Fr. Robartes, n. 334, p. 470. Vid. ſupra Vol. I. C. I. S. XXV.

I. IT has heretofore paſſed for a current Maxim, That all Infinites are equal.

The Poſition nevertheleſs is certainly erroneous, as Dr. *Halley* abundantly has ſhown in the *Philoſophical Tranſactions* for *October* 1696. He there gives divers Inſtances of infinite Quantities which are in a determinate finite Proportion one to another, and ſome infinitely greater one than another. The like may be obſerved of infinitely ſmall Quantities, *viz.* Mathematical Points, as the following Propoſition will make appear.

PROP. I.] *The Points of Contact between Circles and their Tangents, are in ſubduplicate Proportion to the Diameters of the Circles.*

Fig. 1. Let two Circles *a d c b*, *a f b g*, touch one another from within at the Point *a*. Draw the Tangent *p a q*, and parallel to it the Line *m n*. From the Point *a* draw the Diameter *a c*.

Let *a c*, the Diameter of the great Circle, be equal to *R*, and *a b*, the Diameter of the leſſer Circle, be equal to *S*.

Let *d b*, the Chord of the Arch *d a b*, be equal to *z*, and *f g*, the Chord of the Arch *f a g*, be equal to *y*, and let the Abſciſs *a k* be equal to *x*.

If the Line *m n* be ſuppoſed to move till it becomes co-incident with the Tangent *p a q*, the Nature of a Circle will always give the following Equations.

$$zz = 4Rx - 4xx$$
$$yy = 4Sx - 4xx$$

When the Line is arrived at the Tangent, *z* and *y* will become the two Points of Contact, and then $zz = 4Rx$ and $yy = 4Sx$. ($4xx$ being laid aſide as heterogeneous to the reſt of the Æquation, by reaſon of *x* being become infinitely little.) Therefore

$$zz \,.\, yy :: 4Rx \,.\, 4Sx :: R \,.\, S.$$
Therefore $z \,.\, y :: \surd R \,.\, \surd S$. *Q. E. D.*

PROP. II.] *The Point of Contact between a Sphere and a Plane, is infinitely greater than that between a Circle and a Tangent.*

Fig. 2. Let *a* be the Point of Contact between the Sphere *a d q f* and the Plane *b c*. About the Sphere deſcribe the Cylinder *n p g m*.

Draw *k b* to repreſent a Circle parallel to the Plane. Let the Circle be ſuppoſed to move, till it becomes co-incident with the Plane. The Cylindrical Surface *k b g m* will always be equal (according to *Archimedes*) to the Spherical Surface *d a f*.

Now when theſe Surfaces become infinitely ſmall, one terminates in the Point of Contact, and the other in the Periphery of the Baſe of the Cylinder. Therefore the Point of Contact is equal to the Periphery of the Baſe of the Cylinder (equal to a Periphery which has the ſame Diameter as the Sphere) and by Conſequence is infinitely greater than any Point of Contact between a Circle and a Tangent. *Q. E. D.*

PROP. III.] *The Points of Contact by Spheres of different Magnitude are to one another as the Diameters of the Spheres.*

For by the ſecond Propoſition the Points of Contact are equal to the Peripheries of ſuch Diameters, whoſe Proportion is the ſame as the Diameters. *Q. E. D.*

II. Let

Some Properties *of* Conic *Sections deduced from the Nature of* Foci *by Mr.* Ab. de Moivre, n. 352. p. 622. Fig. 3.

II. Let DE be the Tranſverſe Axis of the Ellipſis, AO the other Axis, and C the Center of the Section. Let P be any Point in its Circumference, PQ a Tangent to the Curve at P, meeting the Tranſverſe Axis at Q; the Points S, F; the Foci; CP, CK, Conjugate Semidiameters; PH half the latus rectum to the Diameter PC; PG a Perpendicular to the Tangent; let HG, perpendicular to PCH, meet this in the Point G, ſo that PG may be the Radius of Curvature of the Ellipſis in the Point P. Alſo let ST, CR, and FV, be Perpendiculars let fall upon the Tangent PQ; let SO be joined, and PL a Perpendicular let fall upon the Axis. Theſe Things ſuppoſed, I ſay that,

1. *The Rectangle of the Diſtances from each Focus of the Ellipſis, or* $SP \times PF$, *is equal to the Square of the Semidiameter* CK.

Demonſtration.

$PSq = PCq + CSq - 2CS \times CL$, by 13. II. El.

$PFq = PCq + CSq + 2CS \times CL$, by 12. II. El.

Whence $PSq + PFq = 2PCq + 2CSq$.

Now $PS + PF = DE = 2CD$; and therefore

$PSq + PFq + 2PS \times PF = 4CDq$.

Therefore by Tranſpoſition, $2PS \times PF = 4CDq - 2PCq - 2CSq$.

And by halfing $PS \times PF = 2CDq - PCq - CSq$.

But it is $CSq = CDq - COq$, and therefore

$PS \times PF = CDq + COq - PCq$.

But $CDq + COq = PCq + CKq$; by 12. VII. Conicks of *Apollonius*.

Therefore $PS \times PF = CKq$. *Q. E. D.*

2. *The Diſtance from the Focus* SP *is to the Perpendicular let fall upon the Tangent, as the Semiconjugate* CK *is to the leſſer Semiaxis* CO.

Demonſtration.] Becauſe of ſimilar Triangles SPT and FPV, it will be $PS . PF :: ST . FV$; and componendo, $PS + PF$ to $ST + FV$, or their Halves CD to CR, as PS to ST. Whence $CD \times CK$ to $CR \times CK$ as PS to ST. But $CR \times CK$ is equal to the Rectangle of the Semiaxes $CD \times CO$, by 31. VII. *Conic.* Therefore PS is to ST as $CD \times CK$ to $CD \times CO$, or as CK to CO. And in like Manner it may be demonſtrated, that PF is to FU in the ſame Ratio. *Q. E. D.*

3. *Alſo the Tranſverſe Semiaxis* CD, *to a Perpendicular* CR *let fall from the Center* C *to the Tangent, will be in the ſame Ratio.*

For ſince the Rectangle $CR \times CK$ is equal to the Rectangle $CD \times CO$, as ſaid before; we ſhall have the Analogy CD to CR as CK to CO. *Q. E. D.*

4. *Any Semidiameter* PC *is to the Diſtance of the Point* P *from the Focus* S, *or to* SP, *as the Diſtance from the other Focus* FP *to half the latus rectum belonging to the Vertex* P, *or to* PH.

This is manifeſt by *Prop.* I. ſince the Square of CK is equal to the Rectangle $SP \times PF$.

5. *The Rectangle of the Semiaxes* C D × C O *is to the Square of the Semiconjugate* C K, *as* C K *to the Radius of Curvature* P G *in the Point* P.

For the Triangles PCR, PGH are ſimilar; whence CR is to PC as half the latus rectum PH to PG; that is, by Property 3 aforegoing, $\frac{CD \times CO}{CK} = CR$ is to PC, as $\frac{CKq}{PC} = PH$ is to $\frac{CKc}{CD \times CO} = PG$. Whence this Analogy $CD \times CO \,.\, CKq :: CK \,.\, PG$.

General Theorem 1.] *The Centripetal Force tending to the ſame Point* S, *in all Curves is always proportional to the Quantity* $\frac{SP}{PG \times STc}$

This Theorem was found by me many Years ago, and then communicated to my Friends. Since then it has been confirm'd by the Demonſtrations of the learned Geometricians D. *J. Bernoulli* in the *Leipſic Acts*, D. *J. Keil* in n. 317 of theſe Tranſactions, and by D. *J. Herman* in his *Phoronomia*, p. 70. who may be conſulted.

Vid. *infra* C. IV. S. V.

Now if we write CKc for PG, by *Prop.* 5. and $\frac{SP}{CK}$, by *Prop.* 2. for ST, (becauſe of CD, CO being given) the Centripetal Force tending to the Focus S of the Ellipſis, will always be as $\frac{SP \times CKc}{CKc \times SPc}$, that is as $\frac{SP}{SPc}$, or $\frac{1}{SPq}$; or reciprocally as the Square of SP. Whence it appears if the Section be an Ellipſis deſcrib'd by the Motion of a Body, the Centripetal Force will be reciprocally as the Square of the Diſtance of the Center of Force. From theſe Properties follow ſome Corollaries that may deſerve Obſervation.

Corol. 1.] *The Velocity of a Body revolving in an Ellipſis, at any Point* P, *to the Velocity in a Circle at the ſame Diſtance* S P *from the Center of Force, is in a ſubduplicate ratio of the Diſtance from the other Focus* P F, *to the tranſverſe Semiaxis of the Section, or as a mean Proportional between* P F *and* C D *to* C D.

For the Velocity of a Body revolving in an Ellipſis at the Diſtance SP, to the Velocity of a Body revolving in a Circle or Ellipſis at the Diſtance of the Semiaxis CD or SO, is as CO to ST; that is, by *Prop.* 2. as $\sqrt{PF}$ to $\sqrt{SP}$. But the Velocity of a Body revolving in a Circle at the Diſtance CD, is to the Velocity of a Body revolving in a Circle at the Diſtance SP, as $\sqrt{SP}$ to $\sqrt{CD}$. Therefore *ex æquo* the Velocity of a Body revolving in an Ellipſis at the Diſtance SP, is to the Velocity of a Body revolving in a Circle at the ſame Diſtance, as $\sqrt{PF}$ to $\sqrt{CD}$.

Corol. 2.] *Having given the Velocity in an Ellipſis, the Poſition of the Tangent, and the Focus or Center of Force, it will be eaſy to determine the other Focus.*

For let the given Velocity be R; and let the Velocity by which a Circle would be deſcribed at the given Diſtance SP from the Center be Q, Then by the foregoing Corollary 'tis R to Q as $\sqrt{PF}$ to $\sqrt{CD}$, and therefore QQ is to RR as CD to PF, and $2QQ - RR$ will be to RR as SP to PF. But SP is given, and therefore PF is given in Magnitude. It is alſo given in Poſition, becauſe of the Angle VPF equal to SPT. Therefore the Point F the other Focus is given; which being known, the Section is eaſily deſcrib'd.

Now if $\frac{1}{2}RR$ is greater than QQ, the Quantity $2QQ - RR$ will be negative, and inſtead of an Ellipſis the Trajectory to be deſcribed will be changed into an Hyperbola. And it will be $RR - 2QQ$ to RR, as SP to PF, the Diſtance of the other Focus, to be transferr'd to the other Side of the Tangent, that the Focus F may be had. Now all the Properties which we have demonſtrated in the Ellipſis, changing what ought to be changed, will belong alſo to the Hyperbola.

Now if it ſhould happen that QQ is equal to half the Square of R, then $2QQ - RR = 0$, or the Quantity vaniſhes, or the fourth Proportional PF becomes infinite. Therefore the Trajectory to be deſcribed will be a Parabola, the other *Focus* paſſing to an infinite Diſtance. But the Axis of the Trajectory is given in Poſition, for it is parallel to PF, the Angle FPV being now equal to the given Angle SPT. Fig. 4.

Corol. 3.] *The Velocity of a Body revolving in a given Conic Section, at the Diſtance* SP, *is to the Velocity of the ſame revolving at any other Diſtance* SX, *as a mean Proportional between* FP *and* SX, *to a mean Proportional between* SP *and* FX.

For the Velocity in P is as $\sqrt{\frac{FP}{SP}}$, by *Prop* 2. And by the ſame, the Velocity in X is as $\sqrt{\frac{FX}{SX}}$, whence the Propoſition is manifeſt.

Corol. 4.] *Alſo the Ratio of the Velocities of two Bodies revolving in the ſame Syſtem, but in different given Conic Sections, the Diſtances of each being given from the common Focus of the Orbits, may be eaſily obtain'd by Corol.* 1.

For ſince the Velocity of the Body in P is to the Velocity in a Circle at the ſame Diſtance SP, as $\sqrt{PF}$ is to $\sqrt{CD}$; and in the other ſuppoſed Conic Section, whoſe Semiaxis is cd and Foci S, f; at the Diſtance Sp thoſe Velocities are as $\sqrt{pf}$ to $\sqrt{cd}$; but the Velocity of a Body revolving in a Circle at the Diſtance SP, is to the Velocity in a Circle at the Diſtance Sp, as $\sqrt{Sp}$ to $\sqrt{SP}$; theſe Ratio's being compounded, the Velocity in P will be to the Velocity in p, as $\sqrt{PF \times cd \times Sp}$ to $\sqrt{pf \times CD \times SP}$. Now if the other Section is a Parabola, cd, pf will be infinite, but in the Ratio of 1 to 2. Therefore the Ratio of the Velocities will be as $\sqrt{PF \times SP}$ to $\sqrt{2CD \times SP}$.

Corol. 5.] *If in the Hyperbola the Point* p *paſſes to Infinity, it is plain from the foregoing, that the laſt and leaſt Velocity with which a Body would aſcend for ever, is equal to that with which a Body at the Diſtance* CD, *equal to the tranſverſe Semiaxis, would deſcribe a Circle.*

Corol. 6.] *From the given Diſtance from the Focus, the Poſition of the Tangent is alſo given, or the Angle* S P T *contain'd by the Diſtance* S P *and the Tangent* P T.

For by *Prop.* 2. 'tis PS to ST as CK to CO, or as $\sqrt{SP \times PF}$ to CO; and ſo is Radius to the Sine of Ang. SPT. But in Ellipſes that approach near to Circles, it would be better to ſeek the Angle PST, the Complement of the ſame to a Quadrant. Now the Sine of this is to Radius as $\sqrt{SP \times PF - COq}$ is to $\sqrt{SP \times PF}$.

Corol. 7.] *And hence the Velocities follow with which the Diſtances* S P *increaſe or decreaſe.*

For from the preceding Corollary ſince it is as $\sqrt{SP \times PF}$ to $\sqrt{SP \times PF - COq}$, ſo Radius to the Sine of the Angle PSF; and in the ſame Ratio is the Velocity of the Body in P to the Velocity of the Moment of SP; but that Velocity in P is (by *Prop.* 2.) as $\sqrt{\frac{PF}{SP}}$; omitting the ſuperfluous Quantities, $\frac{\sqrt{SP \times PF - COq}}{SP}$ will always be proportional to the Velocity wherewith the Diſtance SP increaſes or decreaſes.

General Theorem II.] *In every Curvilinear Trajectory the Angular Velocities about the Center of Forces are reciprocally proportional to the Squares of the Diſtances from the Center.*

For becauſe of the equal Areæ of the naſcent Sectors, the Arches ſubtended by theſe leaſt Angles, or the Baſes, are reciprocally as the Radii. Therefore the Angles of theſe leaſt Sectors equal in Area, are to one another in a duplicate Ratio of the Radii reciprocally, or as the Squares of the Diſtances.

Corol 8.] *Hence the Angular Velocities of Bodies revolving in different given Ellipſes may be compared to one another.*

For the Angular Velocities by which Circles would be deſcribed at Diſtances equal to the tranſverſe Semiaxes, are reciprocally in the ſeſquialter Ratio of the Axes, or as $\frac{1}{CD\sqrt{CD}}$. But revolving Bodies have theſe mean Angular Velocities, when the Squares of the Diſtances are equal to the Rectangles of the Semiaxes of the Ellipſes. Therefore by *Theor.* 2. it will be SPq to $CD \times CO$, ſo is $\frac{1}{CD\sqrt{CD}}$ to $\frac{CO}{SPq \times \sqrt{CD}}$; which Quantity is as the Velocity of the Angle at the Center S, deſcribed in a given leaſt Time by the Motion of the right Line SP.

Corol. 9.] *The Angular Velocity by which the Tangent* P T *performs its Rotation, or the right Line* S T *perpendicular to the Tangent, is to the Angular Velocity of the right Line* S P, *as the tranſverſe Semiaxis* C D *is to the Diſtance* P F *from the other Focus.*

Fig. 5. *Demonſtration.*] Let the Points P, p, be very near each other, and drawing SP, Sp, let PT, pt be two Tangents, to which let be drawn the

Perpendiculars ST, St. Parallel to theſe let the Radii of Curvature PG, pG, be drawn, meeting in G; and with Center S and Radius SP let the little Arch PE be drawn, meeting Sp in E. It is evident that the Angle PGp is equal to the Angle TSt, or to the Angular Velocity of the Perpendicular ST. But the Angle PSp is the Angular Velocity of the right Line SP. So that PGp is to the Angle PSp, as the Angular Velocity of ST is to the Angular Velocity of the right Line SP; that is, as $\frac{Pp}{PG}$ is to $\frac{PE}{PS}$. But $Pp \,.\, PE :: SP \,.\, ST :: CK \,.\, CO$, by *Prop.* 2. Therefore theſe Velocities are as $\frac{CK}{PG}$ to $\frac{CO}{PS}$. For PG write $\frac{CK\,cub.}{CD \times DO}$, by *Prop.* 5. and $\frac{CK}{PG}$ will become $\frac{CD \times CO}{CKq} = \frac{CD \times CO}{PS \times PF}$. Hence $\frac{CD \times CO}{PS \times PF}$ will be to $\frac{CO}{PS}$, or expunging what is ſuperfluous, CD to PF, as the Angle TSt is to the Angle PSp, or the Angular Velocity of the Tangent to the Angular Velocity of the Diſtance SP. Therefore the Velocity with which the Tangent revolves will always be proportional to the Quantity $\frac{CO \times \surd CD}{PF \times SPq}$.

In Sect 3. Lib. I. *Of the Principles of Natural Philoſophy, the Reader may find moſt of theſe Corollaries, derived from other Properties of the Conic Sections, or eaſily to be derived from them.*

Tangents to Curves, &c. *by Mr.* H. Ditton, n. 284. p. 1333.

III. I propoſe a Method of Tangents, (immediately derived from the Theory of the *Maxima* and *Minima*,) which is eaſy and ſufficiently general, nay the moſt general of all, as being with the ſame Labour applicable to all Curves. Nor ſhall I ſcruple to call it a new one, ſince no one of the celebrated Geometricians (as far as I have been able to learn) have ever publiſhed any Thing of this Kind. I ſhall here only produce a few Inſtances.

Fig. 6.

Let A G H be a Curve, whoſe Vertex is A, its Axis A K, ordinate F D, and its Center (if it have any) the Point K. Taking L a Point in the Axis, make $AL = n$, $AD = x$, $FD = y$, $FL = z$. Of theſe Quantities the three laſt are flowing Quantities, and n is a conſtant Quantity; for this being always the ſame, anſwers to the others which are always variable. From the right-angled Triangle F D L, we have this Equation, $zz = yy + nn - 2nx + xx$; and determining z to be an Extream, there ariſes $2y\dot{y} - 2n\dot{x} + 2x\dot{x} = 0$; whence by interpreting $2y\dot{y}$ according to the particular Nature of the Curve, the Quantity n will be left, expreſs'd in Terms that will alſo be proper to the Curve.

And now by this Means having z determined to its extreme Value, that is, having the Line F L either the greateſt or leaſt of all thoſe which can be drawn to the Curve from the Point L, and therefore perpendicular to the Curve in the Point F; it is evident that D L is the Subnormal, from whence the Subtangent is eaſily derived.

For an Example let us firſt take the *Apollonian* Parabola, which Curve we will ſuppoſe to be here delineated. Therefore we have $2 y \dot{y} = r \dot{x}$, ſuppoſing r to be the Parameter; whence $r \dot{x} - 2 n \dot{x} + 2 x \dot{x} = 0$, and $n = \frac{r}{2} + x$. Therefore the Subnormal D L $= \frac{1}{2} r$. Now the Meaning of this Theorem is this. If beyond the Limit D of the Abſciſs A D there is taken D L equal to the Semiparameter, and from the Point L be drawn L F ſtrait to the Point F; the right Line ſo drawn will be perpendicular to the Parabola in the Point F, and the leaſt of all the Lines that can be drawn to the Curve from the Point L. I ſay it is the leaſt; for to any one that conſiders the Nature of the Curve, it is evident it cannot be the greateſt, (which I would have obſerved in what follows;) but it is neceſſarily either the greateſt or leaſt, and therefore the latter, And this is the firſt Part of Theor. 5. Lib. 7. of *de la Hire*'s Conicks.

Let the Ordinate E B be drawn, and join the Points E, L. make the intercepted Line B D $= f$, whence A B $= x - f$, and B L $= \frac{r}{2} + f$. Now L E q $= \frac{rr}{4} + rx + ff$, and F L q $= \frac{rr}{4} + rx$. Therefore L E q — F L q = B D q, which is the latter Part of the ſame Theorem.

The nearer the Point F approaches to the Point A, or to the Vertex, in which the Perpendicular cuts the Curve, the nearer alſo the Point L approaches to the ſame. Therefore when F coincides with A, and ſo the Ordinate F D vaniſhes, then the *Minimum* itſelf lies in the Axis A K, and will be equal to the Semiparameter. That is, in this Caſe $n = \frac{1}{2} r$ only; the Abſciſs x belonging to the vaniſhing Ordinate then alſo vaniſhing. If therefore A L $= n = \frac{1}{2} r$, taking the Point D between A and L, make A D $= x$; then there ariſes F L q $= \frac{rr}{4} + xx$, and therefore F L q — A L q $= xx$, that is, F L q — A L q = A D q. As it is Theor. 2. L. 7. Conic. *de la Hire*.

Secondly, Let there be a certain Curve of a ſuperior Parabolic Order, whoſe Equation is $r^{p-q} x^{q} = y^{p}$

Then $yy = r^{\frac{2p-2q}{p}} \times x^{\frac{2q}{p}}$, and therefore

$2 y y$

$2y\dot{y} = \frac{2q}{p} r^{\frac{2p-2q}{p}} x^{\frac{2q-p}{p}} \dot{x}$. Now if we ſubſtitute this Value inſtead of $2y\dot{y}$ in the general Equation, which determines z to be an Extream, we ſhall have from thence

$z = \frac{q}{p} r^{\frac{2p-2q}{p}} x^{\frac{2q-p}{p}} + x$, and therefore the Subnormal is

$DL = \frac{q}{p} r^{\frac{2p-2q}{p}} x^{\frac{2q-p}{p}}$. Now this is eaſily apply'd to any of theſe Curves, if the Indices p and q are rightly expounded, according to the Nature and Genius of each Curve.

Thirdly, let it be ſuppoſed that the Curve is an Ellipſis, of which A K is half the greater Axis. Now it follows from its Equation that $2y\dot{y} = r\dot{x} - \frac{2rx\dot{x}}{q}$. Whence there ariſes $r\dot{x} - \frac{2rx\dot{x}}{q} - 2z\dot{x} + 2x\dot{x} = 0$, and $z = \frac{r}{2} + x - \frac{rx}{q}$. Wherefore $\frac{r - rx}{2q} = DL$ the Subnormal. Now if inſtead of the Ellipſis a Circle were ſubſtituted, by proceeding with the Equation in the ſame Manner, we ſhould find $DL = r - x$, making r to be the Radius of the Circle.

But let us return back to the Ellipſis, another of whoſe Properties may be derived from hence, as was done in the Parabola.

Make $BD = f$, whence $AB = x - f$. Then we ſhall have $LEq = (LBq + EBq =) \frac{rr}{4} - \frac{rrx}{q} + \frac{rrxx}{qq} + ff + rx - \frac{rxx}{q} - \frac{rff}{q}$. And $FLq = (FDq + LDq =) rx - \frac{rxx}{q} + \frac{rr}{4} - \frac{rrx}{q} + \frac{rrxx}{qq}$. Therefore $LEq - LFq = ff - \frac{rff}{q}$. Now this is Theor. 6. Lib. 7. Conic. *de la Hire.*

For that great Geometrician requires, that it may be $q . r :: \frac{q}{2} - x$. L D, whoſe Value therefore is $\frac{r - rx}{2q}$ as found above. Therefore it is a fourth Proportional to the three Quantities before exhibited. This being granted to him he evidently demonſtrates, that L F is the leaſt of all the Lines that can be drawn from the Point L to the Ellipſis. Moreover becauſe it is $q . q - r :: f . f - \frac{fr}{q}$. Therefore the Rectangle $ff - \frac{rff}{q} f \times f - \frac{rf}{q}$ is the ſame Rectangle which D. *de la Hire* calls his Specimen. But this Specimen, (according to his Definition) is a Rectangle like to the Rectangle that conſtitutes the Difference between the Square of the tranſverſe Axis and the Figure, (that is, the Rectangle $qq - qr$,) being beſides apply'd to the right Line B D or f. Now that the Rectangle $ff - \frac{rff}{q}$ has all theſe Conditions is very evident.

It may be obſerved, that it follows from the Value of n before found, that $n > \frac{r}{2}$. For $n = \frac{r}{2} + x - \frac{rx}{q}$. Therefore $qn + rx = \frac{qr}{2} + qx$. But becauſe $q > r$, 'tis $qx > rx$, and therefore $qn > \frac{qr}{2}$, and $n > \frac{r}{2}$.

When the Point *F* (as was juſt now obſerved in the Parabola) falls upon the Vertex *A*, the *Minimum* is determined in the Axis: And becauſe of x vaniſhing, we ſhall have $n = \frac{1}{2} r$. Then aſſuming any Point D between *A* and *L*, if A D is equal to any x, by Compariſon there ariſes $FLq - ALq = xx - \frac{rxx}{q}$. And this is Theor. 3. Lib. 7. of *de la Hire*'s Conicks. For becauſe it is $q . q - r :: x . x - \frac{rx}{q}$, it appears that the Rectangle $xx - \frac{rxx}{q}$ is the Exemplar, but apply'd to the Abſciſs x. And therefore this is the adequate Meaſure of the Defect of the Square of the leaſt Line, from the Square of any other right Line drawn from the ſame Point to the Curve. And this is what he demonſtrates in the Place above cited.

Now the Theorems belonging to the leſſer or conjugate Axis of the Ellipſis, (for hitherto we have inſiſted on the greater or tranſverſe Axis) are determined juſt in the ſame Manner. For now let A K, or half the leſſer Axis, be $\frac{c}{2}$, R the Parameter; and the Point L is now ſuppoſed to be placed beyond the Centre, on the other Side of G K. By working as before, we ſhall find A L or $n = \frac{R}{c} + x - \frac{Rx}{2}$, and the Subnormal $DL = \frac{R}{c} - \frac{Rx}{2}$. That is, $c.\ R :: \frac{c}{2} - x.\ \frac{R}{2} - \frac{Rx}{c}$; and therefore drawing F L, it will be the greateſt of all the Lines that can de drawn from the Point L to the Ellipſis; and $LFq - LEq = \frac{Rff}{c} - ff =$ to the Rectangle, which is the Exemplar, apply'd to B D or f. For it appears that this is the Exemplar, for it is $c.\ R - c :: f.\ \frac{Rf}{c} - f$, and therefore, according to the Definition, $\overline{\frac{Rf}{2} - f} \times f$ is equal to the Exemplar. Now this is Theor. 7. Lib. 7. of *de la Hire*'s Conicks.

Again, when the Point F coincides with A, becauſe of x vaniſhing with the Ordinate then vaniſhing, there is left $n = \frac{R}{2}$, and A L is the greateſt of all the Lines that can be drawn from the Point L to the Ellipſis, and $ALq - FLq = \frac{Rxx}{c} - xx =$ to the Exemplar apply'd to A D or x. And the ſame as to Theor. 4. of Lib. præd. Conicks.

But it ought to be obſerved at the foregoing Caſe, (which ſhould have been mentioned before) when we found $n = \frac{R}{2} + x - \frac{Rx}{c}$, that $n < \frac{R}{2}$. For $cn + Rx = \frac{Rc}{2} + cx$; and becauſe $R > c$, therefore $Rx > cx$, and there will be left $cn < \frac{Rc}{2}$, or $n < \frac{R}{2}$.

Now as the Matter is perform'd in the Ellipſis, ſo in the ſame Manner it might be perform'd in the Hyperbola, and the leaſt Lines may alſo be determined in this Curve. But there is ſuch a Connection between theſe two Curves, and the Tranſition from one to the other is ſo eaſy, that the Labour may ſeem unneceſſary even to Novices. Therefore nothing more remains to determine the Subnormal, than that the Sign − may be changed into +. For ſince in the Hyperbola it is $2y\dot{y} = r\dot{x} + \frac{2rx\dot{x}}{q}$, and $n = \frac{r}{2} + x + \frac{rx}{q}$; (the general Equation) there remains D L $= \frac{r}{2} + \frac{rx}{q}$.

Let it be conceived fourthly, that the Curve M S N (drawn on the other Side the Figure) is one of the Hyperboloids, whoſe Aſymptotes are A K, K H, and the right Line S R an Ordinate to the Aſymptote K H; make S R $= y$, S P $= z$, K R $= x$, K P $= n$, which here muſt needs be leſs than x, as will appear on Conſideration. The Equation proper to the Curve is $y^p x^q = r^q s^p$, inſtead of which, (becauſe of r and s being determinate Quantities) may be wrote $y^p = x^{-q}$, and therefore

$y^2 = x^{\frac{-2q}{p}}$ and $2y\dot{y} = -\frac{2q}{p}\dot{x}x^{\frac{-2q-p}{p}}$ Hence ſince it is

$zz = yy + xx - 2nx + nn$, for an Extream we have

$2y\dot{y} + 2x\dot{x} - 2n\dot{x} = 0$, that is, $-\frac{2q}{p}\dot{x}x^{\frac{-2q-p}{p}}$

$+ 2x\dot{x} = 2n\dot{x}$ and $n = x - \frac{q}{p}x^{\frac{-2q-p}{p}}$

Therefore the Subnormal P R $= (x - n =) \frac{q}{p}x^{\frac{-2q-p}{p}}$.

Laſtly, let us conceive the Curve A F G to be a primary Cycloid, and let the Radius be r, the Arch c, and the Ordinate of the generating Circle to be y, whoſe Diameter may be repreſented by A K, and the Center poſited between L and K. Then calling F D the Ordinate of the Cycloid a, and the reſt as before, the Equation of the Curve is $aa = yy + 2cy + cc$, and therefore $zz = (aa + nn - 2nx + xx =) yy + 2cy + cc + nn - 2nx + xx$, and z being determin'd for an Extream, $2y\dot{y} + 2c\dot{y} + 2y\dot{c} + 2c\dot{c} - 2n\dot{x} + 2x\dot{x} = 0$. But $\dot{y} = \frac{r\dot{x} - x\dot{x}}{y}$, and $\dot{c} = \frac{r\dot{x}}{y}$. Then ſubſtituting theſe Values, and duly reducing the Equation, we ſhall have $2r - x + \frac{2rc - 2xc}{y} + 2r + \frac{2cr}{y} = 2n - 2x$, and therefore $2r - x + \frac{2rc - xc}{y} = n - x =$ D L the Subnormal.

The incomparable Dr. *Barrow* makes uſe of the Subtangent as already known, to determine the *Maximum* and *Minimum*. And Mr. *Newentiit*, in his Analyſis of Infinites, has done the ſame after him. But ſince the *Maxima* and *Minima* may be found by many other Methods, in which nothing need be preſuppoſed about the Tangents of Curves, it is plain that we may ſafely proceed from the *Maxima* and *Minima*, to inveſtigate the Method of Tangents.

Corol. 1.] In going over again the foregoing Examples, it will appear from each, that $2y\dot{y} - 2n\dot{x} + 2x\dot{x} = 0$, by putting inſtead of n in this Equation its Value derived from the Nature of the Curve. For Example in the Hyperboloids

$$\frac{2q}{p}\dot{x} \quad x\,\frac{2q-p}{p} - 2x\dot{x} - \frac{2q}{p}\dot{x}x \quad \frac{2q-p}{p} + 2x\dot{x} = 0,$$

which appears by Inſpection. And the ſame will appear to be true in other Examples, without any Demonſtration.

Corol. 2.] From the Invention of the Subnormals we may eaſily determine the greateſt and leaſt Ordinates of Curves. In which Matter I ſhall add, if the Subnormal belonging to any Point of the Curve be put equal to nothing, we ſhall have the Ordinate of that Curve determin'd to be an Extream. And it will be the greateſt, if it is on the concave Side of the Curve, but the leaſt, if it is on the convex Side. For Example in the Circle, (making the Subnormal $= l$) it will be $l = r - x$. Let $r - x = 0$, then $r = x$ and $y = r$; that is, the greateſt Ordinate is equal to the Radius. In like Manner in the Ellipſis $l = \frac{r}{2} - \frac{rx}{q}$; let $\frac{r}{2} - \frac{rx}{q} = 0$, then $rq = 2rx$, or $x = \frac{q}{2}$. Therefore $yy = \frac{rq}{4}$, equal to a fourth Part of the Figure as they call it, or the Square of the conjugate Semiaxis, and therefore the greateſt y is equal to that Semiaxis. And the ſame Method may be uſed in other Curves. Let the Subnormal be found from the given Equation, and making that equal to nothing, we ſhall have the Ordinate of the Curve determin'd to a *Maximum* or *Minimum*; the firſt towards the concave Part of the Curve, and the other towards the convex Part.

POSTSCRIPT.

Firſt, it will be eaſy by this Method to determine the Tangent, by operating at the convex Side of the Curve, as before on the concave Side.

For let A C be the vertical Tangent, and C a Point in it taken at Pleaſure. Make A C $= n$, C O $= z$, (by which Symbol let all the Lines be denoted, which are drawn from the Point C to the convex Curve A E G.) Then drawing M O always perpendicular to A C, it will be C M $= n - y$. And ſince O M $= x$, it will be $zz = nn - 2ny + yy - xx$; and therefore (for an extream Value of z) $2y\dot{y} + 2x\dot{x} - 2n\dot{y} = o$. In which Equation, if $2x\dot{x}$ be expounded according to the Nature of the Curve, we ſhall have the Line C Z determined, which in this Place performs the Office of a Subnormal. This is too clear to want any Illuſtration by Examples.

Secondly, As in the foregoing Method we have found the Tangents of Curves, by determining to Extreams the Lines L E or C O, drawn from a given Point either in the Axis or in the vertical Tangent; thus by conſidering the Lines Q E, *&c.* drawn from a given Point in the Axis beyond the Vertex, the ſame may be perform'd, and that univerſally. For all the Lines Q E are of a flowing and variable Nature, but the Tangent Q F alone, (ſuppoſing Q F to touch the Curve) is conſtant and determin'd to one Value. Therefore in this Place we ſhall not inſiſt on the Hypotheſis of an Extream, but ſhall only conſider it as a permanent Quantity. Let two Points Q, L, be aſſumed, and thence to the ſame Point of the Curve E let two Lines L E, Q E, be always drawn. The Angle Q E L between the Point of Contact F and the Vertex, will always be obtuſe, but on the other Side of the Point F it will be acute; ſuppoſing, as ſaid before, that Q F touches the Curve, and F L is at right Angles to it. Make Q A $= p$, A L $= n$, A B $= x$, B E $= y$, and Q E $= z$. Alſo V E $= v$, which is intercepted between the Points E and V, where Q V falls perpendicularly from Q upon L E produced. Now becauſe of the obtuſe-angled Triangle Q E, we ſhall have this Equation,

$$zz = pp + 2pn - yy - xx \pm \sqrt{yy + nn - 2nx + xx} \times 2v;$$

or inſtead of $\frac{1}{2}\sqrt{yy + nn - 2nx + xx}$ writing f,

it will be $zz = pp + 2pn - yy - xx + 2nx - 2fv$, and thence

$2z\dot{z} = y\dot{y} - 2x\dot{x} + 2n\dot{x} - 2f\dot{v} - 2v\dot{f}$. Now if z is a conſtant Quantity, in which Caſe Q E will coincide with the Tangent Q F, it will be then $-2y\dot{y} - 2x\dot{x} + 2n\dot{x} = o$, the Rectangle $2fv$, and therefore its Fluxion intirely vaniſhing. But this is the very general Equation, that was determined by the foregoing Method, which is deduced with the ſame Eaſe from the Suppoſition of a conſtant Quantity, as before from the Principle of an extream Quantity.

IV. Let A be the Area of a Curve, whoſe Abſciſs is x, and Ordinate $x^m\sqrt{dx-xx}$. Let B be the Area of a Curve, whoſe Abſciſs is the ſame as the former, but its Ordinate is $x^{m-n}\sqrt{dx-xx}$. Let $\sqrt{dx-xx}=y$, the Area will be

A Method of Squaring *ſome Kinds of* Curves, *by Mr.* Abr. de Moivre, n. 278. *p.* 1113.

$$d^n B\times\frac{2m+1}{2m+4}\times\frac{2m-1}{2m+2}\times\frac{2m-3}{2m}\times\frac{2m-5}{2m-2}, \text{\&c.}=P$$

$$-\frac{1}{m+2}x^{m-1}y^3=-Q$$

$$-\frac{d}{m+1}\times\frac{2m+1}{2m+4}x^{m-2}y^3=-R$$

$$-\frac{d^2}{m}\times\frac{2m+1}{2m+4}\times\frac{2m-1}{2m+2}x^{m-3}y^3=-S$$

$$-\frac{d^3}{m-1}\times\frac{2m+1}{2m+4}\times\frac{2m-1}{2m+2}\times\frac{2m-3}{2m}x^{m-4}y^3=-T, \text{\&c.}$$

Here it is to be obſerved, *firſt*, that n is ſuppoſed to be an integer and affirmative Number. *Secondly*, that the Quantity $d^n B$, in the Series denoted by P, muſt be multiply'd into ſo many Terms as there are Units in n. *Thirdly*, that ſo many of the following Series, denoted by $-Q$, $-R$, $-S$, &c. ought to be taken, as there as Units in n. Now that this may be made plain by an Example or two, I ſay, that if $n=1$, then the Area will be

$$A=d^n B\times\frac{2m+1}{2m+4}-\frac{1}{m+2}x^{m-1}y^3.$$ And if $n=2$, then

$$A=d^n B\times\frac{2m+1}{2m+4}\times\frac{2m-2}{2m+2}-\frac{1}{m+2}x^{m-1}y^3$$
$$-\frac{d}{m+1}\times\frac{2m+1}{2m+4}x^{m-2}y^3$$

Fourthly, if we make $y=\sqrt{dx-xx}$, then $A=Q-R+S-T$, &c. $\pm P$.

Corol. 1.] If m be ſuppoſed equal to any Term of this

$$\text{Series}, -\frac{1}{2}, \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2}, \frac{9}{2}, \text{\&c.}$$

the Quadrature of the Curve, whoſe Ordinate is $x^{m}\sqrt{dx-xx}$, or $x^{m}\sqrt{dx+xx}$ becomes finite, and will be exhibited by our Series. To make this plain by an Example, let the Area of the Curve be ſought, whoſe Ordinate is $x^{-\frac{1}{2}}\sqrt{dx-xx}$. Suppoſe this Curve to be compared with the Curve whoſe Ordinate is $x^{-\frac{3}{2}}\sqrt{dx-xx}$; becauſe in this Caſe $n=1$, therefore

$$A = d^{n} B + \frac{2m+1}{2m+4} - \frac{1}{m+2} x^{m-1} y^{3}.$$

But $m=-\frac{1}{2}$, and therefore $2m+1=0$. So that

$$A = -\frac{1}{m+2} x^{m-1} y^{3} = -\frac{2y^{3}}{3\sqrt{x^{3}}}$$

Here it muſt be obſerved, that the Area thus found will ſometimes be deficient from the true Area, and ſometimes exceed it by a given Quantity. Now that that Exceſs or Defect may become known, let the Area thus found be ſuppos'd to be increaſed or diminiſhed by a given Quantity q, and then putting $x=0$, let the Area thus increaſed or diminiſhed be made equal to 0. Thus in the preſent Caſe q will be found $=\frac{2}{3}d\sqrt{d}$, and therefore

$$A = \frac{2}{3}d\sqrt{d} - \frac{2y^{3}}{3\sqrt{x^{3}}}.$$

Corol. 2.] If n is ſuppoſed equal to any Term of the following Series 3, 4, 5, 6, 7, &c. the Quadrature of the Curve, whoſe Ordinate is $x^{-n}\sqrt{dx-xx}$ or $x^{-n}\sqrt{dx+xx}$, becomes finite, and is exhibited by our Series. Let the Area of the Curve be required, whoſe Ordinate is $x^{-3}\sqrt{dx-xx}$. Suppoſe it to be compared with the Area of the Circle, which may be called A. Then $m=0$, $n=3$, and therefore $A=P-Q-R-S$. But ſince the Quantity $2m$ is infinitely little or nothing, and is found in the Denominator of the third Term by which $d^{n}B$ is multiply'd; the Quantity denoted by P becomes infinite, and for the ſame Reaſon the Quantity denoted by $-S$ becomes infinite; and therefore the Quantities $A, -Q, -R$ vaniſh. Therefore $P=S$.

Now this Equation divided by $\frac{2m+1}{2m+4} \times \frac{2m-1}{2m+2}$ becomes

$d^n B \times \frac{2m-3}{2m} = -\frac{dd}{m} x^{m-3} y^3$ or $d^n B \times \frac{2m-3}{2}$

$= ddx^{m-3}y^3$. And writing 0 and 3 for *m* and *n*, there ariſes

$$dB \times -\frac{3}{2} = \frac{y^3}{x^3}, \text{ or } B = -\frac{2y^3}{3dx^3}.$$

Corol. 3.] If *m* is ſuppos'd equal to any Term of the following Series, — 2, — 1, 0, 1, 2, 3, 4, &c. The Quadrature of the Curve, whoſe Ordinate is $x^m \sqrt{dx - xx}$, depends on the Quadrature of the Circle. But the Area of the Curve, whoſe Ordinate is $x^m \sqrt{dx + xx}$, depends on the Quadrature of the Hyperbola; and the Relation of that Curve to the Circle or Hyperbola, is exhibited by our Series in finite Terms.

Corol. 4.] If *m* is expounded by any other Number different from any before aſſigned, the Curve, whoſe Ordinate is $x^m \sqrt{dx - xx}$ or $x^m \sqrt{dx + xx}$, is neither exactly ſquared, nor depends on the Circle or Hyperbola, but is reduced to a ſimpler Curve by our Series.

Theorem 2.] Let *A* be the Area of a Curve, whoſe Abſciſs is *x* and Ordinate $\frac{x^m}{\sqrt{dx-xx}}$. Let *B* be the Area of a Curve, whoſe Abſciſs is the ſame as the former, but its Ordinate is $\frac{x^{m-n}}{\sqrt{dx-xx}}$. Make $\sqrt{dx - xx} = y$ Then

$$A = d^{-} B \times \frac{2m-1}{2m} \times \frac{2m-3}{2m-2} \times \frac{2m-5}{2m-4} \times \frac{2m-7}{2m-6} \&c. = P.$$

$$-\frac{1}{m} x^{m-1} y = -Q$$

$$-\frac{d}{m-1} \times \frac{2m-1}{2m} x^{m-2} y = -R$$

$$-\frac{d^2}{m-2}\times\frac{2m-1}{2m}\times\frac{2m-3}{2m-2}x^{m-3}y = -S$$

$$-\frac{d^3}{m-3}\times\frac{2m-1}{2m}\times\frac{2m-3}{2m-2}\times\frac{2m-5}{2m-4}x^{m-4}y = -T, \text{ \&c.}$$

The Obſervations made upon the firſt Theorem obtain here alſo, and likewiſe in the following.

Corol. 1.] If m is ſuppoſed equal to any Term of the following Series, $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, $\frac{7}{2}$, $\frac{9}{2}$, &c. the Quadrature of the Curve, whoſe Ordinate is $\frac{x^m}{\sqrt{dx-xx}}$ or $\frac{x^m}{\sqrt{dx+xx}}$, becomes finite, and is exhibited by this Series.

Corol. 2.] If n is ſuppoſed equal to any Term of the following Series, 1, 2, 3, 4, 5, 6, 7, &c. every Curve, whoſe Ordinate is $\frac{x^{-n}}{\sqrt{dx+xx}}$ or $\frac{x^{-n}}{\sqrt{dx+xx}}$ is ſquared in finite Terms by this Series.

Corol. 3.] If m is expounded by any Term of the following Series, 0, 1, 2, 3, 4, 5, &c. the Curve whoſe Ordinate is $\frac{x^m}{\sqrt{dx-xx}}$ depends on the Quadrature of the Circle. But the Curve whoſe Ordinate is $\frac{x^m}{\sqrt{dx+xx}}$ depends on the Quadrature of the Hyperbola. For if Center C, and Diameter $AB = d$, a Circle AEB is deſcrib'd, and $AD = x$ is taken; raiſe the Perpedicular DE, and join CE. The Sector AEC divided by $\frac{1}{4}dd$ is equal to the Area of the Curve whoſe Ordinate is $\frac{x^0}{\sqrt{dx-xx}}$. After the ſame Manner if Center C, and tranſverſe Axis $AB = d$ an equilateral Hyperbola AE is deſcribed; let there be taken

Fig. 7.

Fig. 8.

$AD = x$, let DE be raiſed at right Angles, and CE be join'd. The Sector ACE divided by $\frac{1}{2}dd$ is equal to the Area of the Curve whoſe Ordinate is $\frac{x^0}{\sqrt{dx+xx}}$.

Corol. 4.] If m be ſuppoſed equal to any other Number not within the foregoing Limitations, the Curve whoſe Ordinate is $\frac{x^m}{\sqrt{dx-xx}}$ or $\frac{x^m}{\sqrt{dx+xx}}$, can neither be exactly ſquared, nor does it depend on the Circle or Hyperbola, but however is reduced to a ſimpler Curve.

Theor. 3.] Let A be the Area of a Curve whoſe Abſciſs is x, and Ordinate $x^m\sqrt{rr-xx}$. Let B be the Area of a Curve whoſe Abſciſs is the ſame x, and Ordinate $x^{m-2n}\sqrt{rr-xx}$: make $\sqrt{rr-xx}=y$. Then

$$A = r^{2n}B \times \frac{m-1}{m+2} \times \frac{m-3}{m} \times \frac{m-5}{m-2} \times \frac{m-7}{m-4}, \ \&c. = P$$

$$-\frac{1}{m+2}x^{m-1}y^3 = -Q$$

$$-\frac{r^2}{m} \times \frac{m-1}{m+2}x^{m-3}y^3 = -R$$

$$-\frac{r^4}{m-2} \times \frac{m-2}{m+2} \times \frac{m-3}{m}x^{m-5}y^3 = -S, \ \&c.$$

Corol. 1.] If m is expounded by any Term of the Series 1, 3, 5, 7, &c. the Qnadrature of the Curve whoſe Ordinate is $x^m\sqrt{rr-xx}$, or $x^m\sqrt{rr+xx}$, becomes finite, and is exhibited by this Theorem.

Corol. 2.] If n is interpreted by any Term of the following Series, 2, 3, 4, 5, 6, &c. the Curve whoſe Ordinate is $x^{-2n}\sqrt{rr-xx}$, or $x^{-2n}\sqrt{rr+xx}$, is ſquared exactly by this Theorem.

Corol. 3.] If m is interpreted by any Term of the following Series, −2, 0, 4, 6, 8, &c. the Quadrature of the Curve whoſe Ordinate is

$x^m \sqrt{rr - xx}$, depends on the Circle; and the Quadrature of the Curve whoſe Ordinate is $x^m \sqrt{rr + xx}$, depends on the Hyperbola.

Corol. 4.] If m is interpreted by any Number differing from thoſe afore-mention'd, the Curve whoſe Ordinate is $x^m \sqrt{rr - xx}$, or $x^m \sqrt{rr + xx}$, is neither exactly ſquared, nor depends on the Circle or Hyperbola, but is reduced to a ſimpler Curve.

Theor. 4.] Let A be the *Area* of a Curve whoſe Abſciſs is x, its Ordinate $\frac{x^m}{\sqrt{rr-xx}}$, and let B be the Area of a Curve whoſe Abſciſs alſo is x, and its Ordinate $\frac{x^{m-2n}}{\sqrt{rr-xx}}$. Then

$$A = r^{2n} B \times \frac{m-1}{m} \times \frac{m-3}{m-2} \times \frac{m-5}{m-4} \times \frac{m-7}{m-6}, \&c. = P$$

$$-\frac{1}{m} x^{m-1} y = -Q$$

$$-\frac{r^2}{m-2} \times \frac{m-1}{m} x^{m-3} y = -R$$

$$-\frac{r^4}{m-4} \times \frac{m-1}{m} \times \frac{m-3}{m-2} x^{m-5} y = -S$$

$$-\frac{r^6}{m-6} \times \frac{m-1}{m} \times \frac{m-3}{m-2} \times \frac{m-5}{m-4} x^{m-7} y = -T, \&c.$$

Corol. 1.] If m be expounded by any Term of the following Series, 1, 3, 5, 7, 9, &c. the Quadrature of the Curve whoſe Ordinate is $\frac{x^m}{\sqrt{rr-xx}}$, or $\frac{x^m}{\sqrt{rr+xx}}$ is had by this Theorem in finite Terms.

Corol. 2.] If n is expounded by any Term in the following Series;

1, 2, 3, 4, 5, *&c.* the Curve whoſe Ordinate is $\frac{x^{-2n}}{\sqrt{rr-xx}}$ or $\frac{x^{-2n}}{\sqrt{rr+xx}}$ is perfectly ſquared by this Theorem.

Corol. 3.] If m is expounded by any Term in the following Series, 0, 2, 4, 6, 8, *&c.* the Quadrature of the Curve whoſe Ordinate is $\frac{x}{\sqrt{rr-xx}}$ depends on the Quadrature of the Circle. For if Center C, Radius $CA=r$, a Circle AEG is deſcribed, make DE perpendicular to CD, and join CE; the Sector CAE divided by $\frac{1}{2}rr$ is equal to the Area of a Curve whoſe Ordinate is $\frac{x^0}{\sqrt{rr-xx}}$. In the ſame Manner if C be the Center, $CA=r$ the tranſverſe Semiaxis of an equilateral Hyperbola EAM; draw $CF=x$ perpendicular to AC, draw FE parallel to the Axis till it meets the Hyperbola in E, and join CE. The Hyperbolical Sector ACE divided by $\frac{1}{2}rr$ is equal to the Area of a Curve whoſe Ordinate is $\frac{x^0}{\sqrt{rr+xx}}$.

Corol. 4.] If m is expounded by any Number different from the foregoing, the Curve whoſe Ordinate is $\frac{x^m}{\sqrt{rr-xx}}$, or $\frac{x^m}{\sqrt{rr+xx}}$, is neither ſquared exactly, nor does it depend on the Circle or Hyperbola, but is reduced to a ſimpler Curve.

Theor. 5.] Let A be the Area of a Curve whoſe Abſciſs is x, its Ordinate $\frac{x^m}{d-x}$; and let B be the Area of a Curve whoſe Abſciſs is alſo x, and its Ordinate $\frac{x^{m-n}}{d-x}$. Then the Area will be

$$d^n B - \frac{x^m}{m} - \frac{dx^{m-1}}{m-1} - \frac{d^2x^{m-2}}{m-2}, \text{ \&c.}$$

Let the Ordinate be $\frac{x^m}{d+x}$; the Area will be

$A=$

$$A = \frac{x^m}{m} - \frac{d x^{m-1}}{m-1} + \frac{d^2 x^{m-2}}{m-2}, \text{\&c.} \pm d^{m} B.$$

Corol.] If m is expounded by any Term of the following Series, 0, 1, 2, 3, 4, 5, *&c.* the Quadrature of the Curve whoſe Ordinate is $\frac{x^m}{d-x}$, or $\frac{x^m}{d+x}$, depends on the Quadrature of the Hyperbola.

Fig. 9. For drawing DE and EF at right Angles, take $EG = d$, draw GH perpendicular and equal to EG. Within the Aſymptotes DE, EF, let an Hyperbola be deſcrib'd, paſſing through H, then take $GK = x$ towards E in the firſt Caſe, and towards F in the ſecond, and draw the Ordinate KL. The Area $HGKL$, divided by dd, is equal to the Area of the Curve whoſe Ordinate is $\frac{x^0}{d-x}$ or $\frac{x^0}{d+x}$. Hence the Solid generated by a Portion of the Ciſſoid, revolving about the Diameter of its generating Circle, is exhibited in finite Terms, the Quadrature of the Hyperbola being granted.

Theor. 6.] Let A be the Area of a Curve whoſe Abſciſs is x, its Ordinate $\frac{x^m}{rr+xx}$; let B be the Area of a Curve whoſe Abſciſs alſo is x, and its Ordinate $\frac{x^{m-2n}}{rr+xx}$. The Area will be

$$A = \frac{x^{m-1}}{m-1} - \frac{r^2 x^{m-3}}{m-3} + \frac{r^4 x^{m-5}}{m-5}, \text{\&c.} \mp r^{2n} B.$$

Corol.] If m be expounded by any Term of the following Series, 0, 2, 4, 6, 8, *&c.* the Quadrature of the Curve whoſe Ordinate is $\frac{x^m}{rr+xx}$ depends on the Rectification of the circular Arch. For if Center C, Radius $CB = r$ a Circle AEG be deſcrib'd; draw the Tangent $AK = x$, join CK meeting the Periphery in E. Then the Arch AE divided by rr is equal to the Area of the Curve whoſe Ordinate is $\frac{x^0}{rr+xx}$.

A General Corollary to theſe Six Theorems.

Any Mechanical Curve, whoſe Quadrature depends upon any of the infinite Number of Curves, the Ordinates of which can acquire any of the following Forms,

$$x^m\sqrt{dx\pm xx},\quad \frac{x^m}{\sqrt{dx\pm xx}},\quad x^m\sqrt{rr\pm xx},\quad \frac{x^m}{\sqrt{rr\pm xx}},$$

$\frac{x^m}{d\mp x}$, $\frac{x^m}{rr\pm xx}$, may be ſquared by theſe Series. We ſhall ſhow this by one Example.

Suppoſing that the Cube of the circular Arch, correſponding to the verſed Sine, be made the Ordinate of a Curve, whoſe Abſciſs is the ſame verſed Sine; to find the Area of that Curve.

Let the Abſciſs be x, the circular Arch v; then the Fluxion of the Area will be $v^3\dot{x}$.

Let the Area be $v^3x - q$. Then $v^3\dot{x} + 3v^2\dot{v}x - \dot{q} = v^3\dot{x}$, whence $\dot{q} = 3v^2\dot{v}x$. But $\dot{v} = \frac{d\dot{x}}{2\sqrt{dx-xx}}$, and therefore $\dot{q} = \frac{3dv^2x\dot{x}}{2\sqrt{dx-xx}}$.

But by Theorem the 2d, $\frac{x\dot{x}}{\sqrt{dx-xx}} = \frac{d\dot{x}}{2\sqrt{dx-xx}} - \dot{y} = \dot{v} - \dot{y}$.

So that $\dot{q} = \frac{3}{2}dv^2\dot{v} - \frac{3}{2}dv^2\dot{y}$, therefore $q = \frac{1}{2}dv^3 - \text{Fl.}\ \frac{3}{2}dv^2\dot{y}$.

Therefore we are come to this, that we muſt find the flowing Quantity of $\frac{3}{2}dv^2\dot{y}$.

Let this Quantity be $\frac{3}{2}dv^2y - r$:

Therefore $\frac{3}{2}dv^2\dot{y} + 3dv\dot{v}y - \dot{r} = \frac{3}{2}dv^2\dot{y}$.

Therefore $\dot{r} = 3dv\dot{v}y = \frac{3}{2}d^2v\dot{x}$. Make $r = \frac{3}{2}d^2vx - s$.

Therefore $\frac{3}{2}d^2v\dot{x} = \frac{3}{2}d^2v\dot{x} + \frac{3}{2}d^2x\dot{v} - \dot{s}$.

So that $\dot{s} = \frac{3}{2}d^2\dot{v}x = \frac{3d^3x\dot{x}}{4\sqrt{dx-xx}} = \frac{3}{4}d^3\dot{v} - \frac{3}{4}d^3\dot{y}$, by the ſecond Theorem.

Therefore $s = \frac{3}{4}d^3v - \frac{3}{4}d^3y$. So that the Area required is $v^3x - \frac{1}{2}dv^3 + \frac{3}{2}dv^2y - \frac{3}{2}d^2vx + \frac{3}{4}d^3v - \frac{3}{4}d^3y$.

Now becauſe Solids generated by the Rotation of Curves, Superficies produced by the ſame Rotation, the Rectification of Curves, and the Centers of Gravity of all theſe, depend upon the Quadrature of Curves; theſe will be eaſily computed if they depend upon any of theſe Curves.

After I had put theſe Theorems into Form, and had ſhew'd them to the great *Newton*, as the ſupreme Arbiter of theſe Matters; he was pleas'd to produce to me his own Manuſcripts, by which it appear'd, that he had long been in Poſſeſſion of a Method, by which, when any Trinomial Equation was given, expreſſing the Nature of a Curve, he could either ſquare the ſame, or reduce it to ſome ſimpler Curve.

I queſtion not but thoſe learned Men, whoſe Writings in the Journals of *Leipſick* and elſewhere, have much contributed to the Improvement of the Mathematical Sciences; thoſe Men (I ſay) have Methods akin to theſe, and therefore I aſſume nothing to myſelf, but that I have found theſe Theorems, not knowing whether they may already be extant; and that I have reduc'd them to ſo eaſy a Form, that all the Calculation requir'd is perform'd as it were by Intuition. Before I finiſh writing this, I think it may not be amiſs, if I ſubjoin upon this Occaſion a few Words in Anſwer to the Animadverſions of the learned Mr. *Leibnitz*, upon a certain Series publiſh'd * by me, for finding the Root of an infinite Equation. That famous Man is of Opinion, that that Series is not ſufficiently general, as not reaching the Caſes in which the Quantities z and y are multiply'd into one another; and therefore he ſubſtitutes another Series for mine, which he aſſerts to be infinitely more general than mine. Now I imagine he was led into this ſmall Miſtake, becauſe he took the Quantities a, b, c, d, *&c.* for given Quantities, whereas they may be made Uſe of as given or as indeterminate Quantities at Pleaſure. Let me produce one Example, by which it will appear, that our Series includes all Caſes whatever. Let the Equation be $nyz - z^3 = y^3$. In our Theorem make $a = ny$, $b = o$, $c = -1$, $g = 0$, $h = o$, $i = 1$. Or which is better, make $g = yy$, $h = o$, $i = o$. In either Caſe it will be $z = \frac{y^2}{n} + \frac{y^5}{n^4} + \frac{3y^8}{n^7} + \frac{12y^{11}}{n^{10}}$, *&c.*

* *Of finding the Root of an infinite Equation.* Vid. *ſup.* Vol. I. C. 1. §. xxii.

The Quadrature of a Curve *of the third Order,* communicated *by Mr.* Ab. de Moivre, n. 345. p. 329.

V. I have looked a little farther into that Curve which fell lately under my Conſideration. It is not the *Foliate* as I did at firſt imagine, but I believe it ought not to make a *Species* diſtinct from it. AEB is the Curve I thus deſcribe. Let AB and BK be perpendicular to each other. From the Point A draw AR cutting BK in R, and make $RE = BR$, the Point E belongs to the Curve. Draw BC making an Angle of 45 *grad.* with AB, this Line BC touches the Curve in B; from the Point E draw ED perpendicular to BC, and calling BD, x; DE, y; AB, a; and making $\sqrt{8aa} = n$, the Equation belonging to that Curve,

Fig. 10.

Curve, is $x^3 + xxy + xyy + y^3 = nxy$ or $\frac{x^4 - y^4}{x - y} = nxy$. Taking $BG = AB$, and drawing GP perpendicular to BG, PG is an *Aſymptote.* In the *Foliate* the Equation is $x^3 + y^3 = \frac{1}{3}nxy$, in which the two Terms $xxy + xyy$ of the former Equation are wanting; and its *Aſymptote* is diſtant from B by $\frac{1}{3}BA$. Again, draw EF perpendicular to AB: let BF be called z and FE, v; the Equation belonging to the Curve AEB is $vv = \frac{azz - z^3}{a + z}$. In the Foliate the Equation is $vv = \frac{azz - z^3}{a + 3z}$. From theſe two laſt Equations, it ſeems that theſe Curves differ no more from one another than the *Circle* from the *Ellipſis.*

The Quadrature of the Curve here deſcribed has ſomething of Simplicity, with which I was well pleaſed. With the Radius BA and Center B deſcribe a Circle AKG, let the Square $HPST$ circumſcribe it, ſo that HP be parallel to AG; prolong FE till it meet the Circumference of the Circle in M, and through M draw LMQ parallel to HP. The Area BFE is equal to the Area $KHLM$, comprehended by KH, HL, LM and the Arc KM. And the Area Bfe is equal to the Area $KmLH$ or $KMPQ$. Therefore if BF and Bf are equal, the two Areas BFE, Bfe taken together are equal to the Rectangle HQ, and therefore the whole Space comprehended by $BEAXBeYGZ$ (ſuppoſing Y and Z to be at an infinite Diſtance) is equal to the circumſcrib'd Square HS.

N. B. *This Quadrature is eaſily demonſtrated from the Equation: for by it* $a + z : a - z :: zz : vv$, *that is,* $AF : EF :: MF : FB$, *and ſo* φF *the* Fluxion *of* AF *to* Ll *the* Fluxion *of* MF. *Hence the* Areola $EF\varphi e$ *will be always equal to the* Areola $MLl\mu$, *and therefore the* Area AEF *always equal to the* Area MAL.

Hence it appears that this Curve requires the Quadrature of the Circle to ſquare it; whereas the Foliate *is exactly quadrable, the whole* Leaf *thereof being but one Third of the Square of* AB, *which in this is above three Sevenths of the ſame. Again in our Curve, the greateſt Breadth is when the Point* F *divides the Line* AB *in extreme and mean Proportion: Whereas in the* Foliate *it is when* AB *is triple in Power to* BF. *And the greateſt* EF *or Ordinate in the* Foliate, *is to that of our Curve nearly as* 3 *to* 4, *or exactly as* $\sqrt{\frac{2}{3}\sqrt{\frac{1}{3}} - \frac{1}{3}}$ to $\sqrt{5\sqrt{\frac{5}{4}} - 5\frac{1}{2}}$.

But ſtill theſe Differences are not enough to make them two diſtinct Species, *they being both defined by a like Equation, if the* Aſymptote SGP *be taken for the Diameter. And they are both comprehended under the* fortieth

Kind *of the* Curves *of the* third Order, *as they ſtand enumerated by Sir* Iſaac Newton, *in his incomparable Treatiſe on that Subject.*

A general Method to determine the Quadratures *of Figures by Mr.* J. Craig. n. 284. p. 1346.

VI. I am not a little pleas'd, that the Method which I uſe for determining the Quadrature of Curvilinear Figures, is ſo well approved of by D. D. *Leibnitz* and *Cheyney*; ſo that the firſt acknowledges, it is not unlike the Method found by himſelf, and the other conjectures it has ſome Affinity with the Methods of Mr. *Newton*. He himſelf has purſued the ſame with ſuch Succeſs, that the inverſe Method of Fluxions has been vaſtly improved by him in a Book, which he has dedicated to D. *Archibald Pitcairn*, the Ornament of our Age and Country. But many neceſſary Things yet remain to be diſcover'd, for the Perfection of this inverſe Method. I ſhall now deliver ſome Reaſons in ſhort, which give me Occaſion to think, that what remains cannot be obtain'd by any Methods yet in Uſe.

And firſt, when from the given Relation between z and y, the Fluent of $z\dot{y}$ is required, all thoſe Methods demand, that z may be expreſs'd by y and given Quantities; which yet cannot be done, when the Equation involving that Relation aſcends beyond a Cubic or Biquadratic. For here the vulgar Algebra ſtops, to the great Reproach of that Science. Secondly, tho' a general Rule were known for finding the Roots of Equations of any Degree, yet it would be wholly uſeleſs in this inverſe Method. For the Root z would be involved in ſo many complicated Surds, that by no Art hitherto known we could return from the Fluxion to the Fluent. For theſe Reaſons I have attempted the Thing another Way, and with ſome Succeſs; a Specimen of which I ſhall now impart to the Publick.

Section 1.] Let the Equation expreſſing the Relation between the Ordinate z and the Abſciſs y, be $z^m + ay^n = bz^ry^e$, in which the Exponents m, n, e, r, denote any Numbers, integer or fracted, affirmative or negative. Make $r - n = c$. It will be

$$AREA = \frac{m}{m+n} zy +$$

$$\frac{mc+ne}{m\times\overline{m+n}\times\overline{c+1}+n\times\overline{m+n}\times\overline{e+1}} \times \frac{b}{a} z^{e+1} y^{c+1}$$

$$+ \frac{\overline{m-e}\times\overline{c+1}+r\times\overline{e+1}}{m\times\overline{2c+1}+n\times\overline{2e+1}} \times \frac{Bb}{a} z^{2e+1} y^{2c+1}$$

in =

$$+\frac{\overline{m-e}\times\overline{2c+1}+r\times\overline{2e+1}}{m\times\overline{3c+1}+n\times\overline{3e+1}}\times\frac{bC}{a}z^{3e+1}y^{3c+1},$$

$$+\frac{\overline{m-e}\times\overline{3c+1}+r\times\overline{3e+1}}{m\times\overline{4c+1}+n\times\overline{4e+1}}\times\frac{bD}{a}z^{4e+1}y^{4c+1}$$

$$+\frac{\overline{m-1}\times\overline{4c+1}+r\times\overline{4e+1}}{m\times\overline{5c+1}+n\times\overline{5e+1}}\times\frac{bE}{a}z^{5e+1}y^{5c+1}, \&c.$$

Concerning this Series the following Things are to be obſerved. (1) The Capitals *B*, *C*, *D*, *&c.* denote the Coefficients of the Terms that immediately precede. (2) It exhibits the Quadratures of all quadrable Figures, whoſe Curves are defined by an Equation of three Terms. (3) Now they are always quadrable when $\frac{mr-r}{mn-rm-en}$ is an integer and affirmative Number, which we may call l. (4) Particularly $l+1$ gives the Number of Terms of the Series, to be taken from the Beginning, that conſtitute the required Area. (5) If we ſuppoſe $e=o$, this Series will be changed into the famous Theorem of *Newton* for the common Binomial, which Theorem is therefore a particular Caſe of this Series. (6) When Application is made of this Series to any particular Figure, theſe Rules are to be obſerved. *Firſt*, let the Equation defining the given Curve be reduced to the general Form, and by comparing the particular Equation with the general, let the Coefficients a and b be found, as alſo the Exponents m, n, e, r. *Secondly*, if the Exponents thus determined do not make l an integer affirmative Number, (according to the Condition enjoin'd in Not. 3.) then another Term of the particular Equation is to be freed from the Quantity z, and if the Exponents again determined do not give the Condition of Quadrability required, then the other Term is to be freed from the Quantity z. For every one of the three Terms, conſtituting the given Equation, cannot by any Means be freed from the Quantity z. *Thirdly*, if the aforeſaid Condition of Quadrability does not belong to the Equation, when managed according to the foregoing Rule, then by the Series the Complement of the Area, or Fluent of $y\dot{z}$, muſt be ſought; which being found, the Area required will become known. For it is well known, that zy — flu : $y\dot{z}$ = flu : $z\dot{y}$. And that the Complement may be obtain'd by the Series without any Confuſion, in the given Equation defining the particular Curve, for z we may write Y, and for y may be written Z. And this Change being made of the Ordinate into the Abſciſs, and of the Abſciſs into the Ordinate, the Equation may be managed according to the Precepts of the ſecond Rule, till the Condition of Quadrability is known, or till it appears that no ſuch Condition can be had.

Example 1.] Let $z^3 + y^3 = bzy$. Here becauſe $m = 3$, $n = 3$, $e = 1$, $r = 1$, $a = 1$, therefore $l = 1$, and $l + 1 = 2$. Then according to Not. 4. the two firſt Terms of the Series give the Area $= \frac{1}{2} zy - \frac{1}{6} bz^2 y^{-1}$.

Example 2.] Let $z^7 + ay^3 = bzy^2$. Then $m = 7$, $n = 3$, $e = 1$, $r = 2$; which make $l = 2$. Therefore by Not 4. the three firſt Terms of the Series give the

$$\text{Area} = \frac{7}{10} zy - \frac{b}{15a} z^2 - \frac{2b^2}{15a^2} z^3 y^{-2}.$$

Example 3.] Let $z^3 + ky^5 = bz^{-2}y^{11}$. Here $m = r$, $n = 5$, $e = 2$, $r = 11$; but becauſe theſe do not make l an integer affirmative Number; therefore by the ſecond Rule I free the Term $bz^{-2}y^{11}$ from the Quantity z. Then the Equation becomes $z^5 - by^{11} = -kz^2y^2$, where $a = -b$, $b = -k$, $m = 5$, $n = 11$ $e = 2$, $r = e$; which make $l = 1$; whence the

$$\text{Area} = \frac{5}{16} zy - \frac{5}{16b} z^3 y^{-5}.$$

Example 4.] Let $z^2 - by^2 = -kz^2y^2$. Here $m = 2$, $n = 2$, $e = 2$, $r = 2$; which do not make l an integer affirmative Number. Therefore I free the Term $-kz^2y^2$ from the Quantity z, and then $z^0 + ky^2 = bz^{-2}y^2$. Here $a = k$, $b = b$, $m = 0$, $n = 2$, $e = -2$, which make $l = 1$. Therefore the

$$\text{Area} = \frac{b}{k} z^{-1} y.$$

Example 5.] Let $z^2 - \frac{4g^2}{h} y^6 = -\frac{g}{h} z^2 y^4$; where $m = 2$, $n = 6$,

$e =$

$e = 2$, $r = 4$; which do not make l an integer affirmative Number. And the ſame Thing happens when each of the other Terms is freed from z. Therefore, according to the third Rule, I ſeek the Complement. Then, as before preſcrib'd, making $z = Y$, and $y = Z$, the given Equation becomes

$$Y^2 - \frac{4g^2}{b} Z^6 = -\frac{g}{b} Z^4 Y^2;$$

which by Rule 1, reduced to the general Form will ſtand thus,

$$Z^6 - \frac{b}{4g^2} Y^2 = -\frac{1}{4g} Z^4 Y^2.$$ Here $m = 6$, $n = 2$, $e = 4$, $r = 2$; which do not make l an integer affirmative Number. Therefore by Rule 2, I free the laſt Term from Z; then

$$Z^2 - \frac{l}{4g} Y^2 = \frac{b}{4g^2} Z^{-4} Y^2.$$ Here $m = 2$, $n = 2$, $e = -4$, $r = 2$; whence $l = 1$, $a = -\frac{1}{4g}$, $b = \frac{b}{4g^2}$; whence the Complement of the Area required is

$\frac{1}{2} ZY - \frac{b}{2g} Z^{-3} Y$, or $\frac{1}{2} zy - \frac{b}{2g} zy^{-3}$. And therefore the Area required is *Flu*: $z\dot{y} = \frac{1}{2} zy + \frac{b}{2g} zy^{-3}$.

Section 2.] Let $z^m + ay^n = bz^{2e} y^{2c+n} + fz^e y^{c+n}$ be an Equation, expreſſing the Relation between the Ordinate z and the Abſciſs y. The Area will be

$$Azy + Bz^{e+1} y^{c+1} + Cz^{2e+1} y^{2c+1} + Dz^{3e+1} y^{3c+1} + Ez^{4e+1} y^{4c+1}, \&c.$$

Making here $2c + n = r$, $c + n = s$, it will be $A = \frac{n}{m+n}$;

$$B = \frac{\overline{m - e + s} \times A + \overline{e - m}}{m \times \overline{c + 1} + n \times \overline{e + 1}} \times \frac{f}{a}$$

$C =$

$$C=\frac{\overline{m-2e+r}\times bA+\overline{\overline{m-e}\times\overline{c+1}+r\times\overline{e+1}}\times fB+2eb-mb}{ma\times\overline{2c+1}+na\times\overline{2e+1}},$$

$$D=\frac{\overline{\overline{m-2e}\times\overline{c+1}+r\times\overline{e+1}}\times bB+\overline{\overline{m-e}\times\overline{2c+1}+s\times\overline{2e+1}}\times fC}{ma\times\overline{3c+1}+na\times\overline{3e+1}},$$

$$E=\frac{\overline{\overline{m-2e}\times\overline{2c+1}+r\times\overline{2e+1}}\times bC+\overline{\overline{m-e}\times\overline{3c+1}+s\times\overline{3e+1}}\times fD}{ma\times\overline{4c+1}+na\times\overline{4e+1}},$$

$$F=\frac{\overline{\overline{m-2e}\times\overline{3c+1}+r\times\overline{3e+1}}\times bD+\overline{\overline{m-e}\times\overline{4c+1}+s\times\overline{4e+1}}\times fF}{ma\times\overline{5c+1}+na\times\overline{5e+1}}$$

Concerning this Series, the Progreſſion of which may almoſt be perceived by Inſpection, the following Things are to be obſerved. (1) That thoſe Figures are quadrable, whoſe Curves are defined by the foregoing Equation, when the Exponents *m*, *n*, *c*, *e*, and the Coefficients *a*, *b*, *f*, have the Relations here aſſigned; that is, when $\frac{\overline{2c+m}\times\overline{n-2e}}{-cm+en}$ is an integer and affirmative Number, which we may call l: And l being greater than 2, when the Relation of the Coefficients is as follows.

$$\frac{\overline{m-2e}\times\overline{lc-c+1}+r\times\overline{le-e+1}}{\overline{e-m}\times\overline{lc+1}-s\times\overline{le+1}}\times\frac{bU}{f}=$$

$m=$

$$\frac{\overline{m-2e}\times\overline{lc-2c+1}+r\times\overline{le-2e+1}}{m\times\overline{lc+1}+n\times\overline{le+1}}\times\frac{bP}{a}+$$

$$\frac{\overline{m-e}\times\overline{lc-c+1}+r\times\overline{le-e+1}}{m\times\overline{lc+1}+n\times\overline{le+1}}\times\frac{fU}{a}.$$

Here U and P denote the Coefficients of two Terms, which immediately precede the laſt Term of the Area required. That is, U is the Coefficient of the Term next to the laſt, and P is the Coefficient of the Term remote from the laſt. As if $Fz^{5e+1}y^{5c+1}$ were the laſt Term of the Area required, then U would denote E, and P would denote D. (2) That laſt Term of the Area required is known from the Value of the Number l; for here alſo $l+1$ gives the Number of the Terms of the Series, which are to be taken from the Beginning, which conſtitute the Area required. (3) If $l=1$, then the Relation of the Coefficients muſt be this:

$$\frac{\overline{2e-m}\times\overline{1-A}+rA}{\overline{e-m}\times\overline{c+1}-s\times\overline{e+1}}\times\frac{b}{f}=\frac{\overline{e-m}\times\overline{1-A}+sA}{m\times\overline{c+1}+n\times\overline{e+1}}\times\frac{f}{a}.$$

If $l=2$, the Relation muſt be this:

$$\frac{\overline{m-2e}\times\overline{c+1}+r\times\overline{e+1}}{\overline{e-m}\times\overline{2c+1}+s\times\overline{2e+1}}\times\frac{bB}{f}=$$

$$\frac{\overline{2e-m}\times\overline{1-A}+rA}{m\times\overline{2c+1}+n\times\overline{2e+1}}\times\frac{b}{a}+$$

$m-$

$$\frac{\overline{m-e}\times\overline{c+1}+s\times\overline{e+1}}{m\times\overline{2c+1}+n\times\overline{2e+1}}\times\frac{fB}{a}.$$

Section 3.] Let $z^{m} = ay^{n} + bz^{e}y^{c+n} + fz^{2e}y^{2c+n} + gz^{3e}y^{3c+n}$, *&c.* be the Equation expreſſing the Relation between the Ordinate z and the Abſciſs y, and conſiſting of as many Terms as you pleaſe; the Area will be

$$Azy + Bz^{e+1}y^{c+1} + Cz^{2e+1}y^{2c+1} + Dz^{3e+1}y^{3c+1} + Ez^{4e+1}y^{4c+1},$$

&c. which (if I miſtake not) is no contemptible Theorem. The Coefficients A, B, C, D, E, &c. are found by a very eaſy Calculation, as alſo the Conditions of Quadrability, and how many Terms of the Series the Area requires. The Number of theſe Conditions increaſes, with the Number of the Terms of which the Equation conſiſts, which defines the Relation of z and y. And particularly, if that Number of Terms is called N, then $N-2$ will be the Number of the Conditions of Quadrability; one of which ſhews the Relation of the Exponents m, n, e, c, when

$$\frac{Nc-2c+2e-Ne+m+n}{-cm-en}$$

is an integer and affirmative Number, which we call l. The other Conditions regard the Coefficients a, b, f, g, h, &c. And laſtly, $l+1$ gives the Number of the Terms of the Series, to be taken from the Beginning, which conſtitute the Area required.

Corol.] From this general Series, a Series may be deduced, which ſhall exhibit the Quadratures of Figures, whoſe Curves are defined by an Equation conſiſting of any Terms, which conſtitute the general Equation of the third Section. For to obtain this there is Need only to compute a Series for an Equation conſiſting of ſo many Terms of the general Equation taken from the Beginning, as the Equation defining the Curves includes Terms. Then from the Values of the Quantities A, B, C, &c. the Coefficients b, f, g, &c. may be eliminated, which do not belong to the Equation propoſed. The others will give the Area required. This will appear by an Example.

Section 4.] Let $z^m = ay^n + bz^e y^{c+n} + gz^{3e} y^{3c+n}$ be an Equation expreſſing the Relation between z and y. Now becauſe

$$z^m = ay^n + bz^e y^{c+n} + fz^{2e} y^{2c+n} + gz^{3e} y^{3c+n}$$

is that Part of the Equation which includes the given Equation, taking the Terms in Order from the Beginning, which hereafter (for Brevity Sake) I will call the compleat Equation: Therefore the Areas of the Figures, whoſe Curves are defined by the compleat Equation, will be

$$Azy + Bz^{e+1} y^{c+1} + Cz^{2e+1} y^{2c+1} +$$

$$Dz^{3e+1} y^{3c+1} + Ez^{4e+1} y^{4c+1} + Fz^{5e+1} y^{5c+1} \text{ \&c.}$$

Here the Coefficients a, b, f, g, enter the Values of the Quantities B, C, D, E, F, &c. If therefore in theſe Values we put every where $f = o$, (becauſe $fz^{2e} y^{2c+n}$ does not enter the given Equation) we ſhall have the Values of the Quantities A, B, C, D, E, &c. which being ſubſtituted in the Series will give the Areas required. Now by the Calculation I have found that

$$A = \frac{m}{m+n}. \qquad B = \frac{c - \overline{m-c-n} \times A + m - e}{m \times \overline{c+1} + n \times \overline{e-1}} \times \frac{b}{a}$$

$$C = \frac{\overline{e+n} \times \overline{e+1} + \overline{m-e} \times \overline{c+1}}{m \times \overline{2c+1} + n \times \overline{2e+1}} \times \frac{bB}{a},$$

$$D = \frac{\overline{\overline{m-3e} \times \overline{1-A} + \overline{3c-n}} \times -Ag}{ma \times \overline{3c+1}}$$

$$\frac{+\overline{\overline{m-e}\times\overline{2c+1}+\overline{c+n}\times\overline{2e+1}}\times-bC}{+na\times\overline{3e+1}}$$

$$E=\frac{\overline{\overline{m-3e}\times\overline{c+1}+\overline{3c+n}\times\overline{e+1}}\times}{ma\times\overline{4c+1}}$$

$$\frac{-gB+\overline{\overline{m-e}\times\overline{3c+1}+\overline{c+n}\times\overline{3e+1}}\times-bD}{+na\times\overline{4e+1}}$$

$$F=\frac{\overline{\overline{m-3e}\times\overline{2c+1}+\overline{3c+n}\times\overline{2e+1}}\times}{ma\times\overline{5c+1}}$$

$$\frac{-gC+\overline{\overline{m-e}\times\overline{4c+1}+\overline{c+n}\times\overline{4e+1}}\times-bE}{+na\times\overline{5e+1}}$$

$$G=\frac{\overline{\overline{m-3e}\times\overline{3c+1}+\overline{3c+n}\times\overline{3e+1}}\times}{ma\times\overline{6c+1}}$$

$$\frac{-gD+\overline{\overline{m-e}\times\overline{5c+1}+\overline{c+n}\times\overline{5e+1}}\times-bF}{+na\times\overline{6e+1}}$$

From hence appears the Progreſſion of the reſt *in infinitum*. And thus will be had a Series exhibiting the Quadratures of all the Figures, whoſe Curves are defined by this Equation of four Terms,

$$z^{m}=ay^{n}+bz^{e}y^{c+n}+gz^{3e}y^{3c+n}.$$

And it muſt be obſerved, that the Conditions of Quadrability, and the Number of the Terms of the Series that conſtitute any Area ſought, are the ſame with the Conditions of Quadrability, and Number of the Terms, which agree to the Figures whoſe Curves are defined by compleat Equations.

Corol.] Beſides theſe two Series in §. 2 and 4 for Figures of four Terms, in the ſame Manner infinite other Series may be computed for other Caſes of Figures of four Terms, which is alſo to be underſtood of all other Figures, whoſe Curves are defined by Equations conſiſting of any Number of Terms.

I have not Time at preſent to give a minute Deſcription of the Method, by which I arrive at theſe Series; yet to give ſome ſhort Account of it perhaps may not be amiſs. I aſſume a Series compoſed alike of z and y, ſuch as this following.

$$Azy + Bz^{p}y^{q} + Cz^{s}y^{h} + Dz^{l}y^{k}, \text{ \&c.} = \textit{Fluent} \text{ of } z\dot{y};$$

of which all the Terms except the firſt have general Exponents. Then I form an Equation between two Values of the Quantity $\dot{z}$, one of which is derived from this Series, and the other is eaſily found by the direct Method of Fluxions, from the Equation exhibiting the Relation between z and y. From the Terms of this Equation duly reduced, firſt I determine the general Exponents p, q, g, h, l, k, &c. and then the Coefficients A, B, C, &c. And if there are more Compariſons than what are ſufficient for determining theſe Coefficients, from the reſt I deduce the Conditions of Quadrability. If you proceed the right Way, the Calculation will be very eaſy; and I have many Rules relating hereto, which perhaps I may give another Time: As alſo the Uſe of this Method in finding finite irrational Quadratures, when rational ones cannot be had. For the whole Affair is now in my Power.

VII. *The Solution of a Problem propoſed by Mr.* Jo. Bernoulli, *in a* French *Journal*, Feb. 1703.

Problem.] A Geometrical Curve being propoſed, to find others without Number which are equal to it in Length.

To find other Curves equal in Length to any given Geometrical *Curve, by Mr.* J. Craig, n. 289. p. 1527.

Solution. Let the Co-ordinates of the given Curve be w, s, and thoſe of the Curve required be $x\,y$. Then from the Condition of the Problem it will be $\dot{w}\dot{w} + \dot{s}\dot{s} = \dot{x}\dot{x} + \dot{y}\dot{y}$. Let us ſuppoſe $\dot{x} = \dot{w} - m\dot{z}$, then it ill be $\dot{y} = \sqrt{\dot{s}^2 + 2m\dot{w}\dot{z} - m^2\dot{z}^2}$. In this Equation inſtead of $\dot{s}$ let s Value be ſubſtituted and expreſſed by w, $\dot{w}$, and determinate Quanti- es; and for $\dot{z}$ let ſuch a Value be aſſumed, compoſed of w; $\dot{w}$, and eterminate Quantities, as that the Fluents of $\dot{x}$ and $\dot{y}$ may be found. Thus x and y, the Co-ordinates of the Curve ſought, will be had. *Q. E. I.*

Example 1.] To find a Curve equal to the Parabolic Line. Let $2a$ be the latus rectum of the Parabola. Then $2as = w^2$, or $s = \frac{w^2}{2a}$ whence $\dot{s} = \frac{w\dot{w}}{a} = a^{-1}w\dot{w}$, and $\dot{s}^2 = a^{-2}w^2\dot{w}^2$, and therefore $\dot{y} = \sqrt{a^{-2}w^2\dot{w}^2 + 2m\dot{w}\dot{z} - m^2\dot{z}^2}$. That the Fluent of this may be found, aſſume $m\dot{z} = \frac{w^2\dot{w}}{a^2}$, whence $\dot{x} = \dot{w} - a^{-2}w^2\dot{w}$, and $\dot{y} = \sqrt{3a^{-2}w^2\dot{w}^2 - a^{-4}w^4\dot{w}^2} = \dot{w}\sqrt{3a^{-2}w^2 - a^{-4}w^4}$. Now the Fluents of theſe, by Methods already known, will be found to be $x = w - \frac{w^3}{3a^2}$, and $y = \frac{w^2 - 3a^2}{3a^2}\sqrt{3a^2 - w^2}$.

Example 2.] To find a Curve equal to the Circular Arch. Let a be the Radius of the Circle; then 'tis $s = \sqrt{a^2 - w^2}$; whence $\dot{s}^2 = \frac{w^2\dot{w}^2}{a^2 - w^2}$, and therefore $\dot{y} = \sqrt{\frac{w^2\dot{w}^2}{a^2 - w^2} + 2m\dot{w}\dot{z} - m^2\dot{z}^2}$. That the Fluent of this may be found, let us aſſume $m\dot{z} = \frac{4w^2\dot{w}}{a^2}$, and therefore $\dot{x} = \dot{w} - \frac{4w^2\dot{w}}{a^2}$, and $\dot{y} = \frac{-3a^2w + 4w^3}{a^2\sqrt{a^2 - w^2}} \times \dot{w}$. Now the Fluents of theſe are $x = w - \frac{4w^3}{3a^2}$, and $y = \frac{a^2 - 4w^2}{3a^2}\sqrt{a^2 - w^2}$.

Example 3.] To find a Curve equal to that of an Ellipſis. Let $2r$ be the latus rectum, a the tranſverſe Axis. Then $s = \frac{r\sqrt{a^2 - w^2}}{a}$, whence $\dot{s}^2 = \frac{r^2w^2\dot{w}^2}{a^4 - a^2w^2}$, and therefore $\dot{y} = \sqrt{\frac{r^2w^2\dot{w}^2}{a^4 - a^2w^2} + 2m\dot{w}\dot{z} - m^2\dot{z}^2}$. That the Fluent may be had, make $m\dot{z} = \frac{2a + 2r}{a^3}w^2\dot{w}$; whence $\dot{x} = \dot{w} - \frac{2a + 2r}{a^3}w^2\dot{w}$, and $\dot{y} = \dot{w} \times$

√

$\sqrt{\frac{r^2 w^2}{a^4 - a^2 w^2} + \frac{4a + 4r}{a^3} w^2 + \frac{\overline{2a+2r}|^2}{-a^6} w^4}$; the Fluents of which, to be found by known Methods, are $x = w - \frac{2a + 2r}{3a^3} w^3$, and $y = \frac{2a^3 - ra^2 - 2aw^2 - 2rw^2}{3a^2} \sqrt{a^2 - w^2}$.

Example 4.] To find a Curve equal to the Cubical Parabola, whoſe Equation is $3a^2 s = w^3$. Thence $\dot{s}^2 = \frac{w^4 \dot{w}^2}{a^2}$, and therefore $\dot{y} = \sqrt{a^{-4} w^4 \dot{w}^2 + 2m\dot{w}\dot{z} - m^2 \dot{z}^2}$. Now in order to find a Fluent, make $m\dot{z} = \frac{w^2 \dot{w}}{2a^2}$. Hence $\dot{x} = \dot{w} - \frac{w^2 \dot{w}}{2a^2}$, and $\dot{y} = \frac{w\dot{w}}{2a}\sqrt{3w^2 + 4a^2}$. The Fluents of theſe are $x = w - \frac{w^3}{6a^2}$, and $y = \frac{1}{18a} \times \overline{3w^2 + 4a^2}|^{\frac{3}{2}} = \frac{w^2}{6a} + \frac{2}{9} a \times \sqrt{3w^2 + 4a^2}$.

From other infinite Values of the Quantity $m\dot{z}$ rightly aſſumed, may infinite Curves be derived, which are equal to the given Curve. And it may be obſerved, that this Problem has ſome Kind of Affinity with a certain Problem of *Diophantus*. His Problem is, to divide the Sum of two Squares into two other Squares, having their Sides rational. And *Bernoulli*'s Problem is, to divide the Sum of two Squares into two other Squares, the Fluents of whoſe Sides may be found. As the Solution of of *Diophantus*'s Problem depends only on the vulgar Algebra, ſo the Solution of *Bernoulli*'s Problem requires only the common inverſe Method of Fluxions. The Artifice of each conſiſts in a due Aſſumption of the Sides required; that of *Diophantus* that the Sides may be rational, that of *Bernoulli* that the Fluents of the Sides may be found.

VIII. The *Circle*, *Ellipſis* and *Hyperbola* being not geometrically quadrable (as infinite others) there have been two Ways made uſe of to find their *Area's*. By *Converging Series*, whereby Approaches are made nearer and nearer, according to the Exactneſs deſired. 2. By *Quadratrices*, that is, mechanical Curves, which determine the Length of certain Lines, whoſe Squares or Rectangles give the *Area* of the Figure deſired. Of this Sort is the old *Quadratrix* of *Dinoſtratus*, by which the Circle and Ellipſe are ſquared; and another Sort (for the ſame Purpoſe)

A new Quadratrix *to the* Hyperbola, *by Mr.* Perks, n. 306. p. 2253.

Vid. ſupra, V. 1. C. 1. S. VII. I inſerted in the *Tranſactions* about five Years ago. Since that, having found the Conſtruction of a Curve, from whence (beſides its own *Quadrature* and *Rectification*) the *Quadrature* of the *Hyperbola* is derived, I thought the following Account might not (to ſome) be unacceptable.

Fig. 11. Let *A B*, *C D*, be two ſtrait Rulars joined at *B*, and there making a right Angle. (Their Length according to the Largeneſs of the Figure you will deſcribe.) *E F* is another Rular ſomewhat longer than *A B*. Near the one End *E*, let a little *Truckle-Wheel* (repreſented edge-wiſe by *g b*, and made of a thin Plate of Braſs or Iron) be faſtened to the Rular by a Pin (*i*,) through its Center, ſo that the Wheel may turn about upon the Pin (*i*) tight to the Rular without joggling.

On the under Side of this Rular (the Side from the Eye in the Scheme) let there be pinn'd or glewed a little Piece of Wood (in the Form of a Quadrant, the Part which is ſeen being marked *k l*) whoſe Edge (or Limb) *k l*, is an Arch of a Circle of Center (*i*,) and *Radius i b* (the ſame with the little Wheel.) The Deſign of this Piece of Wood is, that in the ſeveral Poſitions of the Rular *E F*, the circular Limb *k l* always touching and ſliding by the Edge of the Rular *A B*, the Center of the Wheel may be always in a Line (*i m*) parallel to the Rular *A B*.

In the Rular *C D* make $MB = ib$ or ik, and at *M* faſten a little Pin, and another to the Rular *E F* near the Wheel, as at *P*. To theſe two Ends let be faſtened the two Ends of a String *M R*, ſo that its whole Length (from Pin to Pin) $+ Pi$, be equal to the intended Axis of the Curve *T W*.

The Inſtrument being thus prepared, let a ſtrong Rular *S O*, be faſtened (or held faſt) upon the Paper or Plane that the Curve is to be drawn upon. Lay the Rular *E F* from *M* towards *A*, and parallel to *A B*, ſo that the String lie all ſtrait along the Edge of the Rular *E F* from *M* to *p*, the Point *S k* of the Quadrantal Piece of Wood reſting upon the Edge of the Rular *A B*. Then with a ſmall Pin at *M* keeping the String cloſe to the Edge of the Rular *E F*, and with your other Hand upon the End *E*, keeping the Wheel tight to the Paper or Plane, move the Pin, String and Rular *E F* from *M* towards *O*, the Rular *C D*, ſliding along by the faſtened Rular *S O* in a right Line, the Wheel *g b* will by its Motion deſcribe the defined Curve *T V*.

Note, The Semidiameter of the little Wheel muſt be about the *Sum* of the Thickneſſes of the two Rulars *E F* and *A B*, that it may touch the Paper. Alſo it will be convenient that its Edge be thin, and a little rough, that it may not ſlide flat-ways, and that it may leave a viſible Impreſſion.

From this Conſtruction the following Properties are demonſtrable:

1. It is evident from the Conſtruction, that the *Sum of the Tangent and Subtangent* is every where equal to the ſame given Line ($= MR + Ri = TW$,) for the String (firſt ſtrait at *T W*, afterwards making an Angle at *R*)

at *R*) being every where the ſame; the Line *R i* (or $R P + P i$) is always the Tangent, and the Remainder *R M* the Subtangent; the Contact of the Wheel with the Plane, being the Point of the Curve to which they belong.

2. It hence follows, that any aſſignable Part of the Curve is *rectifiable*, or equal to any aſſignable ſtrait Line. In *Fig.* 12. Let *F A E* be a Part of the Curve, its Vertex *F*. *H D d* is the Line deſcrib'd by the Motion of the Pin *R* (in *Fig* 11.) and may be ſhewn to be aſymptote to the Curve. *F H* a Perpendicular to *H D*. Let *A* be the given Point in the Curve, *A D* the Tangent, and *B D* the Subtangent to the ſame Point *A*. Let *a* be another Point in the Curve infinitely near to *A*, to which let *a d* be the Tangent, and *b d* the Subtangent. Draw *A G a g* perpendicular to *F H* and *A B*, *a b* perpendicular to *H D*. By the Conſtruction $AD + DB = ad + db$. Let $a\delta$ be made equal to *a D*, and draw $D\delta$. Then becauſe $ad + bd = AD + DB$. Subſtract *b D* and *a D* (or $a\delta$) from both Sums (Equals from Equals) there remains $\delta d + dD = Aa + Bb$ (or *C a*). *A a C*, $Dd\delta$ are like Triangles (or differing infinitely little from ſuch) therefore $Ca\ (Bb) : Aa :: \delta d : Dd$, and compounding $Bb + Aa : Aa :: \delta d + Dd : Dd$. Alternating $Bb + Aa : \delta d + Dd :: Aa : Dd$. But $Bb + Aa = \delta d + Dd$ (as is ſhewn above) therefore $Aa = Dd$. *A a* is the fluxional Particle of the Curve *F A*, and *D d* is the fluxional Particle of the Line *H D*: Theſe Fluxions or Augments being equal, and their flowing Quantities beginning together, are themſelves therefore equal, *viz.* $FA = HD$.

Let $FG = x$. $GA\ (= HB) = y$. $AD = t$. $BD = S$. So is the Curve $FA = HD = y + S$: that is, *the Curve from the Vertex to any given Point therein, is equal to the Sum of its Ordinate, and Subtangent to the ſame Point which is its ſecond Property.*

3. The next Property (and whereupon I call it the *Hyperbolic Quadratrix*) is this: Let *F A E* be a Part of the Curve, &c. (as before.) Fig. 12. *F I K H* is a Square upon the Line *F H*. A I L is an Equilater Hyperbola, whoſe Vertex is *I*, its Aſſymptotes *H O*, *H R*; its Axis $HI\mu$. From a given Point *L* in the Hyperbola (below its Vertex *I*) draw *L A* parallel to the Aſſymptote *R H*, interſecting the Diagonal *I H* in *M*, *F H* in *G*, and touching the Quadratrix in *A*. I ſay, that the Hyperbolic Area *I L M* is equal to a Rectangle, whoſe Sides are the Ordinate *G A*, and twice *F H*, the Axis to the Quadratrix, that is, Trilin. $ILM = 2FH \times GA$.

Let $FH = a$, $FG = x$, $GA = y$. Becauſe of the Hyperbola *G L X* $GH\ (LS) = FHq$, therefore $GL = \frac{FHq}{GH}$; and $LM = \frac{FHq}{GH} - GH\ (MG)$ that is, $LM = \frac{aa}{a\ x} - a + x = \frac{2ax - xx}{a - x}$, and conſequently ly the Fluxion of the Area $ILM = \frac{2ax - xx}{a - x}\dot{x}$

In the Rectangle Triangle ADB, $AB = a - x$, $BD = S$, $AD = t = a - S$; then is $ADq = ABq + BDq$: or $aa - 2aS + SS = aa - 2ax + xx + SS$, which being thus reduced, gives

$$S = \frac{2ax - xx}{2a}$$

Let la be a right Line ſuppoſed infinitely near and parallel to LA, and interſecting AB in C. Becauſe of like Triangles ACa, ABD; $AB : BD :: AC : Ca$, that is $a - x : S \left(= \frac{2ax - xx}{2a}\right) :: \dot{x} : \dot{y}$.

therefore $\dot{y} = \frac{2ax - xx}{2aa - 2ax}\dot{x}$. Multiply each by $2a$, and 'tis $2a\dot{y} = \frac{2ax - xx}{a - x}\dot{x}$. The flowing Quantity of $2a\dot{y}$ is $2ay$, and the flowing Quantity of $\frac{2ax - xx}{a - x}\dot{x}$ is the Hyperbolic Area ILM (as is ſhewn before.) Theſe two Area's beginning together at F and I, and having every where equal *Fluxions*, or Augments, are therefore themſelves every where equal.

N. The Quadrature of the Trilinear Figure ILM being thus found, any other Area bounded with the Curve-line IL, and any other Right Lines is alſo given.

4. Suppoſing the ſame Things as in the precedent Propoſition, I ſay, that the Area of the Quadradrix $FabHF$ is equal to half the Square of Fg, wanting the Cube of Fg divided by $6FH$, or $FabHF = \frac{xx}{2} - \frac{xxx}{6a}$. The Fluxion of this Area is the Rectangle $CabB = \overline{a - x} \times \dot{y} = \overline{a - x} \times \frac{2ax - xx}{2aa - 2ax}\dot{x} = x\dot{x} - \frac{xx}{2a}\dot{x}$. The flowing

Quantity of $x\dot{x}$

Quantity of $\dot{x}x$ is $\frac{1}{2}xx$: And the flowing Quantity of $-\frac{xx}{2a}\dot{x}$ is $-\frac{xxx}{6a}$ [as is eaſily ſhewn by bringing back theſe flowing Quantities to their reſpective Fluxions.] And hence alſo it follows, that the whole Area continued on infinitely towards *E*, is *one third of the Square FIKH*; or $\frac{1}{3}aa$. For ſuppoſing $x = a$, the Area above becomes $\frac{aa}{2} - \frac{aa}{6} = \frac{aa}{3}$.

While I was conſidering the other Properties of this Curve, and had given ſome Account of them to my ingenious Friend Mr. *John Colſon*, he returned me a Letter with the Addition of the Quadrature of the Curves Area, which I had not then enquired into.

5. Suppoſing ſtill the ſame Things, I ſay that the Solid made by the Converſion of the Area *FabHF* about the Line *Hb* as an Axis, is equal to a Cylinder whoſe Radius is $FH = a$, and Height equal to $\frac{xx}{2a} - \frac{x^3}{2aa} + \frac{x^4}{8a^3}$. And the whole Solid made by Converſion of the whole Figure infinitely continued, is equal to an eighth Part of a Cylinder, whoſe Radius and Height are each equal to *FH* or *a*.

Let $\frac{P}{D}$ expreſs the Proportion of the Periphery and Diameter of a Circle. Then is $\frac{P}{D}ab$ quad. the Area of a Circle whoſe Radius is *ab*. And becauſe $Ca = y = \frac{x - \frac{xx}{2a}}{a - x}\dot{x}$ the Fluxion of the Solid is $\frac{P}{D} \times ab$, q. $\times \frac{x - \frac{xx}{2a}}{a - x}\dot{x}$, or $\frac{P}{D} \times \overline{a - x}^2 \times \frac{x - \frac{xx}{2a}}{a - x}\dot{x} = \frac{P}{D} \times \overline{ax - \frac{3}{2}xx + \frac{x^3}{2a}} \times \dot{x}$;

whoſe flowing Quantity is $\frac{P}{D} \times \frac{a x^2 - x^3}{2} + \frac{x^4}{8a}$. Which Solid being divided by $\frac{P}{D} a a$ (the Area of a Circle whoſe Radius is a) gives $\frac{xx}{2a} - \frac{xxx}{2aa} + \frac{x^4}{8a^3}$ for the Height of a Cylinder on the ſaid circular Baſe, and equal to the Solid made by Converſion of the Area $FabHF$ about the Line Hb as an Axis. When $x = a$ (that is, when the whole Figure is turn'd about its Aſymptote) the Height $\frac{xx}{2a} - \frac{x^3}{2aa} + \frac{x^4}{8a^3}$ becomes $\frac{1}{8} a$.

6. The Curve Surface of the Solid generated by the Converſion of the Figure $FabHF$ about HB, is equal to the Curve Surface of a Cylinder whoſe Radius is a, and Height equal to $\frac{x}{2} - \frac{xx}{4a} + \frac{xxx}{12aa}$. And the whole Curve Surface of the Solid infinitely continued, is equal to *one third Part of the Curve Surface of a Cylinder whoſe Radius and Height are equal to* F H or a. Which may be demonſtrated after the Manner of the precedent Propoſition.

7. The Radius of the Curvature of any Particle of the Quadratrix is
Fig. 13. $\frac{tt}{a-x}$ and this found Geometrically. FAE is the *Quadratrix*, HD the Aſymptote, AD the Tangent, BD the Subtangent to a given Point A. Make $BV = AD$. Upon V raiſe the Perpendicular VW, from A draw AW perpendicular to the Tangent AD, till it meet AW in W. So is A W the Radius of the Curvature at A.

8. This Curve may be continued on infinitely above the Point F (but by a different and more operoſe Way of Conſtruction) whoſe Properties will be theſe. 1. The *Difference* of its Tangent and Subtangent (taking the Subtangent in the Line HS) will be always equal to the ſame given Line FH or a. That is, as $t + s = a$, below F, ſo $t - s = a$ above F.

2. As below F the Curve Line is equal to the *Sum* of its Ordinate and Subtangent, ſo above, it is equal to their *Difference*, or $s - y$. 3. As below F, $2\,a\,y = I\,L\,M$, ſo above, $2\,a\,y = I\,\lambda\,\mu$. All which (and its other Properties) may be demonſtrated as the Precedent *mutatis mutandis*.

9. With a little Variation in the precedent Conſtruction, may the *Logarithmick Curve* be conſtructed, which is alſo a *Quadratrix* to the Hyperbola. Omitting the String $M\,R\,P$, let the Diſtance $M\,R$ be equal to the *Subtangent* of the intended Logarithmick Curve (which, as it is known, is invariable.) Stick a Pin at R in the Rular $C\,D$, to which apply the Rular $E\,F$, ſo that the Edge of the little Quadrant $k\,l$, reſting upon the Rular $A\,B$, the Diſtance $M\,i$ be equal to $M\,R$. Then keeping the Rular $E\,F$ tight to the Pin R and Rular $A\,B$, ſlide the Rular $C\,D$ along in a ſtrait Line (by the Rular or Line $S\,O$.) So will the Wheel $g\,h$ deſcribe a Part of the Logarithmick Curve $T\,V$, whoſe *Subtangent* is every where $M\,R$. Fig. 11.

10. Let $F\,A\,E$ repreſent the *Logarithmick Curve*, whoſe Subtangent is equal to $F\,H$. $L\,I\,\Lambda$ is an Equilater Hyperbola (&c. as before §. 3.) Let $F\,G = x$, $G\,a = y$. $F\,H\,(= B\,D) = a$. $G\,H\,(= L\,S) = a - x$. $A\,C = \dot{x}$, $C\,a = \dot{y}$. Then $A\,C : C\,a :: A\,B : B\,D$, that is $\dot{x} : \dot{y} :: a - x : a :: a : \frac{a\,a}{a - x}$ therefore $a\,\dot{y} = \frac{a\,a}{a - x}\,\dot{x}$. The flowing Quantity of $a\,\dot{y}$ is $a\,y$; and the flowing Quantity of $\frac{a\,a}{a - x}\,\dot{x}$ is the Hyperbolick Area $F\,I\,L\,G$ (for by the Nature of the Hyperbola $G\,L = \frac{a\,a}{a - x}$) therefore it the Hyperbolick Area $F\,I\,L\,G$ equal to $a\,y$ a Rectangle, whoſe Sides are the Subtangent ($B\,D = F\,H$) and Ordinate $G\,A$ (as here accounted) of the Logarithmick Curve. Fig. 12.

IX. Lemma.] *To divide the Sum of two Squares into two other Squares.* *Of the Length of Curve Lines, by Mr.* J. Craig, n. 314, p. 64.

Let z^2 and s^2 be two given Squares whoſe Sum is $z^2 + s^2$. It is to be divided into two other Squares x^2 and y^2; and let m and n be any two Numbers taken at Pleaſure. Now from the Condition of the Problem it is $x^2 + y^2 = z^2 + s^2$; whence (as may appear from *Diophantus*)

$$\dot{x} = \frac{\overline{mm-nn}\times\dot{z}+2mn\dot{s},}{mm+nn}, \text{ and}$$

$$\dot{y} = \frac{\overline{nn-mm}\times\dot{s}+2mn\dot{z}}{mm+nn}. \text{ Q. E. J.}$$

Problem.] *To find innumerable Curves, which are of the ſame Length with any propoſed Curve, whether Algebraical or Mechanical.*

Let z and s repreſent the Co-ordinates of the Curve propoſed; x and y the Co-ordinates of the Curve required, which is to be of the ſame Length as the Curve propoſed. Therefore it is evident from the Elements of Curves, that $\dot{x}^2+\dot{y}^2=\dot{z}^2+\dot{s}^2$; and therefore by the foregoing Lemma

$$\dot{x} = \frac{\overline{mm-nn}\times\dot{z}+2mn\dot{s}}{mm+nn},$$

$$\dot{y} = \frac{\overline{nn-mm}\,\dot{s}+2mn\dot{z}}{mm+nn};$$

The Fluents of which are

$$x = \frac{\overline{mm-nn}\times z+2mns}{mm+nn},$$

$$y = \frac{\overline{nn-mm}\,s+2mnz}{mm+nn}.$$

And thus the Co-ordinates x and y of one of the Curves required will become known; and in like Manner from this a ſecond may be derived, and from the ſecond a third, and ſo on, till as many as you pleaſe are found. *Q. E. J.*

I

I add no Examples now, becauſe there will be a fitter Occaſion hereafter, in which this Method ſhall be apply'd to ſeveral Problems of this Kind, and the Solution of this Problem ſhall be illuſtrated by a Variety of Examples. And I have ſo plainly pointed out this Solution more than once, that it might eaſily have been deduced, by any one verſed in theſe Matters, from what is ſubjoin'd to the Solution of a particular Caſe of this Problem, in which the Curve propoſed is Algebraical, and which I exhibited in the Philoſophical Tranſactions for *Jan.* 1704. So that it may appear to Mr. *Jo Bernoulli*, the learned Propoſer of the Problem, that its Solution may be obtain'd from the common Rules of the inverſe Method of Fluxions, ſince he inſinuated, in his private Letters to Dr. *Cheyney*, that the ſame could not be exhibited by our Theorems publiſh'd in the Philoſophical Tranſactions for *March* 1703. And becauſe I perceive from the Acts of *Leipſick* of *Auguſt* 1705, that our Solution did not pleaſe that learned Man, though enough, and more than enough to the Purpoſe; for that Reaſon only I publiſh the foregoing Solution, which can be liable to no Objection. Therefore the learned *Bernoulli* muſt ingenuouſly acknowledge, that hardly any Problem can be propoſed, the Solution of which is deduced with more Eaſe from the inverſe Method of Fluxions, than this his Problem of the Transformation of Curves.

Vid. *ſup.* S. VII.

Vid. *ſup.* S. VI.

Now I ſhall declare, in a few Words, what I cannot approve in Mr. *Bernoulli*'s Solution of his own Problem. *Firſt*, That he has apply'd it only to Algebraical Curves. *Secondly*, That it is Mechanical, and depending wholly upon what he calls *Creeping Motion*. *Huygens* is certainly deſerving of immortal Honour, for his Invention of the Motion of Evolution, becauſe from thence not only himſelf but others have derived admirable Theorems Geometrically. But neither *Leibnitz*'s Motion of Traction, nor *Bernoulli*'s Creeping Motion, will ever be comparable to *Huygens*'s Motion of Evolution, till thoſe ingenious Men, as *Huygens* has done, ſhall reduce the Curves generated by their Motions to the Laws of Geometry. Now, ſince neither of them have yet perform'd this, the Solutions of Problems, depending upon Curves produced by their Motions, can only be reputed as Mechanical.

X. In the *Acta Eruditorum* for *October* 1698. pag. 471. Mr. *J. Bernoulli* writes thus. “ At length I have obtain'd the general Method
“ I wiſh'd for, for the orderly cutting of Curves given in Poſition,
“ whether Algebraical or Tranſcendental, in an Angle either right or
“ oblique, whether invariable or varying according to a given Law;
“ to which, according to the Opinion of Mr. *Leibnitz*, not a Jot can be
“ added for its farther Perfection, and for this Reaſon, that it always
“ leads to an Equation. In which, if the indeterminate Quantities are
“ ſometimes inſeparable, the Method is not the leſs perfect for that;
“ for it belongs not to this, but to ſome other Method to ſeparate them.

A General Solution of a Problem *concerning* Curves, *by* ---- n. 347. p. 399.

“ I

“ I intreat my Brother, that he will try his Strength in a Matter of this Weight; nor will he repent of his Labour, if he happens to be ſucceſsful. I know he will then forſake the Method he is now ſo fond of, which can only be apply'd in a very few Occaſions.

Theſe three great Men had been uſed to exerciſe one another, for about the Space of four or five Years, in propoſing and ſolving ſuch Kind of Problems. It would be very difficult to give the very ſame Solution as that of Mr. *Bernoulli*, without one had the Spirit of Divination. It is ſufficient that the following Solution is general, and always brings us to an Equation.

Problem.] *A general Method is required for finding a Series of Curves, which ſhall cut at a given Angle, or at an Angle that ſhall vary in a given Law, Curves that are conſtituted in any other given Series.*

Solution.] The Nature of the Curves to be cut gives the Tangents of the ſame at any Points of Interſection; and the Angles of Interſection give the Perpendiculars of the cutting Curves; and two Perpendiculars coinciding, by their laſt Concourſe give the Center of Curvity of the cutting Curve at the Point of any Interſection. Let an Abſciſs be drawn in any convenient Situation, and let its Fluxion be Unity; and the Poſition of the Perpendicular will give the firſt Fluxion of the Ordinate belonging to the Curve required; and the Curvity of this Curve will give the ſecond Fluxion of the ſame Ordinate. And thus the Problem will always be reduced to Equation. *Q. E. F.*

Scholium.] It does not belong to this, but to another Method, to reduce the Equations, and to ſeparate the indeterminate Quantities, abſolutely if it may be done, if not, by infinite Series. As this Problem is hardly of any Uſe, for that Reaſon it has remain'd neglected and unſolved for many Years, in the *Acta Eruditorum*. And for the ſame Reaſon I ſhall not proſecute its Solution any farther.

Mr. Leibnitz's Problem *concerning* Curves, *ſolv'd by Dr.* B. Taylor, n. 354. p. 695.

XI. Since the deceaſed Mr. *G. G. Leibnitz*, in the Controverſy lately moved about the Inventer of the Method of Fluxions (which he has thought fit to call the Differential Method, and obſtinately to appropriate the Invention to himſelf) has given no Anſwer to thoſe Arguments which are alledged in Favour of Mr. *Newton*, as the Diſcoverer of that noble Method; yet by his Encouragement Mr. *Joh. Bernoulli* has propoſed a Problem, to be ſolved by the *Engliſh* Geometricians. But whether the Problem is ſolved by them or no, it can be no Prejudice to the Right of Mr. *Newton*. However, leaſt they ſhould make it an Occaſion of Triumph, if this Problem ſhould not be attempted by the *Engliſh*, I have ventured to give my Solution, ſuch as it is, tho' the Problem is no ways remarkable either for its Uſe or Difficulty.

The Problem at firſt propoſed by Mr. *Leibnitz* was ſo underſtood, as if nothing elſe had been required, than that Conic-Hyperbola's, deſcrib'd with the ſame Center and Vertices, ſhould be cut at right Angles. But when he was inform'd, that this Caſe had been immediately ſolved by ſome *Engliſh-men*, he wrote Word, that the Solution of a particular Caſe was not required, but a general Solution. For which Reaſon thoſe particular Solutions were not publiſh'd; tho' in the Philoſophical Tranſactions Numb. 347. [*See Sect.* X. *above*] a Solution appear'd which was univerſal. But Mr. *Leibnitz* and his Aſſociates were not content with this, but ſeem'd rather to deſpiſe it, as if the Author was not able to apply it to any particular Caſe. If they could not perceive how Equations were to be deduced from it, that is to be imputed to their Unſkilfulneſs. A little before the Death of Mr. *Leibnitz* the following Problem at laſt came out, which may be ſolved after different Manners, by purſuing the Steps of the general Solution before-mentioned; but at preſent we ſhall ſolve it as follows.

Problem.] *Upon the right Line* A G *as an Axis, from the Point* A *to draw an infinite Number of Curves, ſuch as* A B D, *which are to be of ſuch a Nature, that the Radii of Curvature* B O, *drawn every where in the ſeveral Points* B, *may be cut by the Axis* A G *in* C, *in a given Ratio, or ſo that it may be* B O . *B C* :: 1 . n. Fig. 14.

Then are to be conſtructed the Trajectories E B F, *which ſhall cut the former Curves* A B D *at right Angles.*

Firſt Part of the Solution.] To find the Curves *A B D*, which are to be cut. 1. Drawing the Ordinate *B H* perpendicular to the Axis *A G*, make the Abſciſs *A H* = *z*, the Ordinate *H B* = *x*, the Curve *A B* = *v*. Then by the direct Method of Fluxions it will be $BC = \frac{\dot{v} x}{\ddot{z}}$, and if *v* flows uniformly, $BO = \frac{\dot{v} \dot{x}}{\ddot{z}}$. Whence by the Condition of the Problem 'tis $BO \left(\frac{\dot{v} \dot{x}}{\ddot{z}}\right) . BC \left(\frac{\dot{v} x}{\dot{z}}\right) :: 1 . n$, and therefore $\ddot{z} x - n \dot{z} \dot{x} = 0$.

2. This Equation being compared with the ſecond formula of Fluxions, at the End of *Prop.* 6. of the Method of Increments, there is found $\dot{z} x^{-n} = \dot{v} a^{-n}$; *a* being a given Line, by the Value of which the Curve *A B D* may be accommodated to any Condition that is annex'd to the Problem.

3. Inſtead of $\dot{v}$ its Value $\sqrt{\dot{x}^2 + \dot{z}^2}$ being written, the Equation $\dot{z} x^{-n} = \dot{v} a^{-n}$ is changed into this $\dot{z} = \frac{\dot{x} x^n}{\sqrt{a^{2n} - x^{2n}}}$. Whence *z*

is given when x is given, by the Quadrature of the Curve, whoſe Abſciſs being x, its Ordinate is $\frac{x^n}{\sqrt{a^{2n}-x^{2n}}}$.

4. Let σ and τ be integer Numbers, either affirmative or negative, ſuch as that the ſimpleſt of the Curves produced in this Manner may be that, whoſe Abſciſs is y, and Ordinate is $y^{\frac{1-n+2\sigma n}{2n}} \times \overline{-y)}^{\tau-\frac{1}{2}}$; then it will be the ſimpleſt of all the Curves, by the Quadrature of which the Abſciſs z is given from the given Ordinate x.

5. The Curve *A B D* is a Geometrical Curve, as often as the Reciprocal of any odd Number is aſſumed for n.

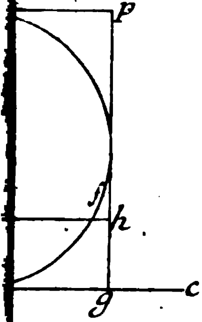
6. Hitherto we have conſidered the Curve *A B D* as concave towards the Axis *A G*, in which Caſe the greateſt Ordinate x is equal to the given right Line a, which we may conveniently call the Parameter of the Curve. And in this Caſe the Curve will actually meet the Axis. Whence the Fluent of $\frac{\dot{x}x^n}{\sqrt{a^{2n}-x^{2n}}}$ being rightly taken, that is, ſo that z and x may vaniſh together, the Curve will paſs through the given Point *A*, as the Problem requires.

7. But if a Curve *A B D* be required, which is convex towards the Axis, in the ſame Manner we ſhall come to the Equation $\dot{z} = \frac{a^n\dot{x}}{\sqrt{x^{2n}-a^{2n}}}$; which alſo may be derived from the former Equation, by changing the Sign of n. And in this Caſe the Curve *A B D* is Geometrical, as often as the Reciprocal of any even Number is taken for n. But in this Caſe the leaſt Ordinate x is equal to the Parameter a; and therefore the Curve no where meets with the Axis. Therefore the Problem is limited to the former Caſe.

8. From the foregoing it is eaſily concluded, that all the Curves *ABD* are ſimilar, and ſimilarly poſited about the given Point *A*, their homologous Sides being proportional to the Parameters a.

The other Part of the Solution: Or the Invention of the cutting Curve.

9. From §. 2. tis $v . \dot{z} :: a^n . x^n$. But it is $BC . BH :: v . \dot{z}$. Therefore it is $BC . BH :: a^n . x^n$. But from the Condition of the Problem *B C* is a Tangent to the Curve ſought *E B F*. Wherefore if we take now *A H* (z) and *B H* (x) for Co-ordinates of the Curve *E B F*, the Curve itſelf *E B* being call'd r; it will be by the direct Method of Fluxions $\dot{r} . -\dot{x} :: (BC . BH ::)\ a^n . x^n$. Whence it is $\frac{x^n}{a^n} = \frac{-\dot{x}}{\dot{r}}$.



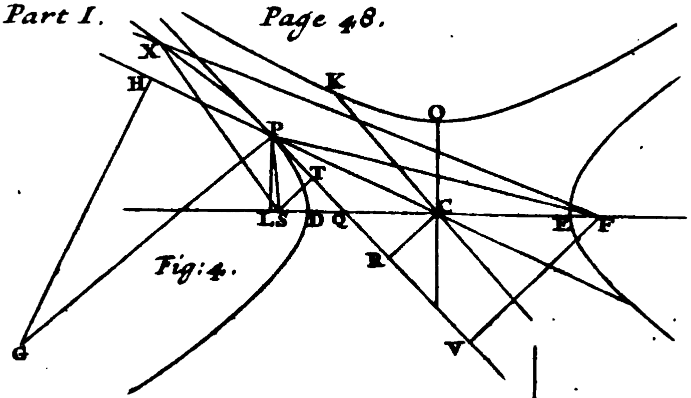


Fig: 4.

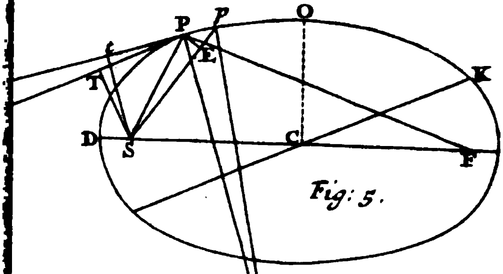


Fig: 5.

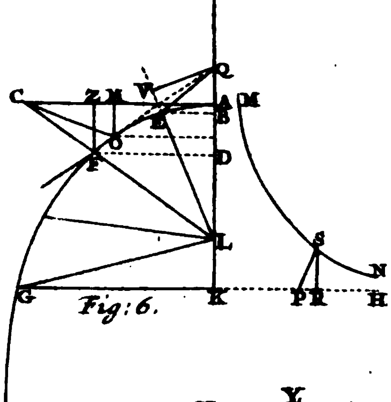
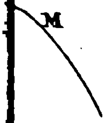


Fig: 6.



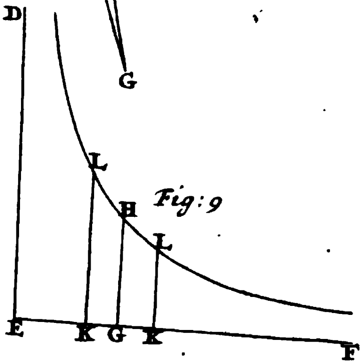


Fig: 9

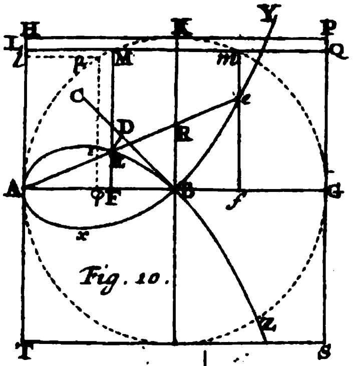
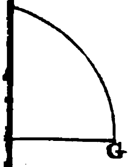


Fig. 10.



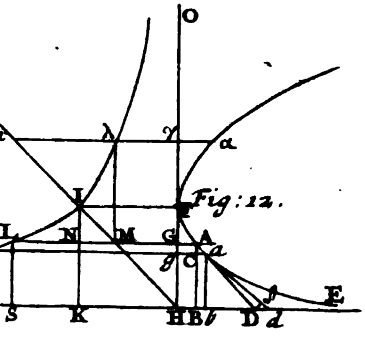


Fig: 12.

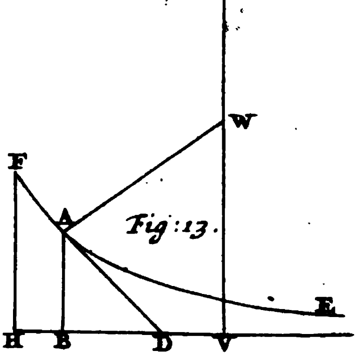


Fig: 13.

10. In the Curve *ABD* imagine the Equation $\dot{z} = \frac{\dot{x}x^n}{\sqrt{a^{2n} - x^{2n}}}$ to be transform'd into the Equation $\dot{z} = \frac{A\dot{x}x^n}{a^n} + \frac{B\dot{x}x^{3n}}{a^{3n}} + \frac{C\dot{x}x^{5n}}{a^{5n}}$, &c. which is not affected with Radical Signs; then by returning to the Fluents it will be $z = \frac{1}{n+1} \times \frac{Ax^{n+1}}{a^n} + \frac{1}{3n+1} \times \frac{B\dot{x}^{3n+1}}{a^{3n}} + \frac{1}{5n+1} \times \frac{Cx^{5n+1}}{a^{5n}}$, &c. where no new Coefficient is introduced, becauſe by the Condition of the Problem z and x are naſcent at the ſame Time. Here inſtead of $\frac{x^n}{a^n}$ ſubſtituting its Value $\frac{-\dot{x}}{\dot{r}}$, as found §. 9. we ſhall have $z = \frac{1}{n+1} Ax \times \frac{-\dot{x}}{\dot{r}} + \frac{1}{3n+1} Bx \times \frac{-\dot{x}^3}{\dot{r}^3}$, &c. which is a fluxional Equation of the firſt Degree belonging to the Curve required *EBF*. Now this is reduced to a more ſimple Form in finite Terms after the following Manner.

11. Let r flow equably, and a being a conſtant Quantity, make $\frac{-\dot{x}}{\dot{r}} = \frac{s^n}{a^n}$. This Value of $\frac{-\dot{x}}{\dot{r}}$ being ſubſtituted in the Equation laſt found, and the Equation being multiply'd by $\frac{s}{x}$, it will be transform'd into this $\frac{zs}{x} = \frac{1}{n+1} \times \frac{As^{n+1}}{a^n} + \frac{1}{3n+1} \times \frac{Bs^{3n+1}}{a^{3n}}$, &c. whence taking the Fluxions, it will be $\frac{\dot{s}zx + s\dot{z}x - sz\dot{x}}{x^2} = A\dot{s} \times \frac{s^n}{a^n} + B\dot{s} \times \frac{s^{3n}}{a^{3n}}$, &c. $= \frac{\dot{s}s^n}{\sqrt{a^{2n} - s^{2n}}}$. This laſt is manifeſt from the Analogy of the Series $A\dot{x} \times \frac{x^n}{a^n}$, &c. and $A\dot{s} \times \frac{s^n}{a^n}$, &c. Here for s and $\dot{s}$ ſubſtituting their

Values derived from the Equation $\frac{-\dot{x}}{\dot{r}} = \frac{s^n}{a^n}$, there will ariſe the Equation $n\dot{x}^2 \dot{z} z - \ddot{x} x \dot{z} z + n \dot{x} x \dot{z}^2 - \ddot{x} \dot{x} x^2 = 0$; which is reduced to firſt Fluxions in the following Manner.

12. In the laſt Term $-\ddot{x}\dot{x}x^2$ inſtead of $\ddot{x}\dot{x}$ writing its Value $-\ddot{z}\dot{z}$, and then applying the Equation to z, there ariſes $n\dot{x}^2 z - \ddot{x} x z - n \dot{x} x \ddot{z} + x x \ddot{z} = 0$. Which Equation multiply'd by x^{-n-1} is the Fluxion of the Equation $-\dot{x} x^{-n} z + x^{1-n} \dot{z} = a^{1-n} \dot{r}$, the Quantities a and $\dot{r}$ being conſtant. Therefore this Equation, or $\overline{\dot{z} x - z \dot{x}} \times a^{n-1} = \dot{r} x^n$ is a fluxional Equation of the firſt Degree, belonging to the Curve ſought *E B F*.

13. Now in this Equation a is the Value of the Ordinate *B H*, when the Point *H* falls in the Point *A*.

14. It will not be very eaſy, while n continues to be general, to bring this Equation to an Equation involving only Fluents, or to the Quadrature of Curves. But the Points of the Curve *E B F* may conveniently be found by the Deſcription of the Curve *A B D*, and of a certain Geometrical Curve. By a Geometrical Curve I underſtand one, into whoſe Equation no Fluxions enter, nor Fluents into the Indices of the Powers. For let the Curve *A B D*, whoſe Parameter is a, be cut in *B* by a Geometrical Curve whoſe Equation is $a a^n x^n - z a^n x^n = x a^n \sqrt{a^{2n} - x^{2n}}$; then that Point of Interſection *B* will be in one of the Trajectories ſought, which paſſes through the Point *E*; *A E* being equal to a, and perpendicular to *A G*.

15. Hence if *A B D* be a Geometrical Curve, *E B F* will alſo be a Geometrical Curve.

Scholium. The Equation $\overline{\dot{z} x - z \dot{x}} \times a^{n-1} = \dot{r} x^n$ may be found another Way. For by a certain Analyſis, which at this Time I think fit to conceal, I have found the Equation $\frac{\dot{a}}{a} = \frac{\dot{r}\dot{r}}{\dot{z} z + x \dot{x}}$, which being compared with the Equation $\frac{x^n}{a^n} = \frac{-\dot{x}}{\dot{r}}$ (§. 9.) by eliminating a and $\dot{a}$, we at laſt arrive at the foregoing Equation $\overline{\dot{z} x - z \dot{x}} \times a^{n-1} = \dot{r} x^n$.

Example. A very ſimple Example may ſuffice to prove the Truth of this Solution. Make $n = 1$, in which Caſe *A B D* will be a Semicircle

deſcrib'd

deſcribed with the Diameter AG; alſo EBF will be a Semicircle likewiſe, deſcrib'd with the Diameter AE. But in this Caſe $\frac{\dot{x}x^n}{\sqrt{a^{2n}-x^{2n}}} = \frac{\dot{x}x}{\sqrt{a^2-x^2}}$. Whence in §. 3. 'tis $\dot{z} = \frac{\dot{x}x}{\sqrt{a^2-x^2}}$. Therefore $z = a - \sqrt{a^2-x^2}$, which is an Equation to a Circle, deſcribed with the Diameter $AG = a$, as it ought to be. Alſo for n writing 1, the Equation $\overline{\dot{z}x - z\dot{x}} \times a^{n-1} = \dot{r}x^n$ is changed into $\dot{z}x - z\dot{x} = \dot{r}x$. Whence exterminating $\dot{r}$ by Means of the Equation $\dot{r}\dot{r} = \dot{x}\dot{x} + \dot{z}\dot{z}$, there ariſes $\frac{2\dot{z}zx - \dot{x}z^2}{x^2} = -\dot{x}$, and therefore returning to the Fluents, it will be $\frac{zz}{x} = -x + a$, which is an Equation to a Circle deſcribed with Diameter $AE = a$, as it ought to be.

XII. Whereas in every Curve Line there is a certain Regularity of Curvature, tho' perhaps involved, according to which the Figure is determin'd; therefore Geometricians define the various Characters of Curves, by an Equation expreſſing the Relation of the Ordinates to the Abſciſſes of any Axis or Diameter. Now ſince the ſame Thing may be done from the Conſideration of the Curves in reſpect of one given Center, nay the moſt ſimple Uniformity of Nature often requires this ſhould be done in this Inquiry; therefore we ſhall have Recourſe at preſent to this Method of conſidering Curves, and firſt we ſhall ſhew, how eaſy it will be (according to this Method of determining Curves, by the Aſſiſtance of the Arithmetick of Infinites) to derive the more complicate from the ſimple ones.

Conſtruction and Meaſure of Curves, by Mr. C. Mac-laurin, n. 356. p. 803.

Sect. 1.] Let the Points L and l be as near as may be in the Curve BlL; let lo be an Arch deſcribed with Center S, perpendicular to SL, and Ll will be as the Moment of the Curve, and Lo the Moment of the Radius SL. And if the Ratio of Ll to Lo be given, or to lo in the Diſtance SL, the Equation of the Curve will be given at the Center S. Let LP, lp, be Tangents to the Curve in the Points L and l, upon which from S let be drawn the Perpendiculars SP, Sp, meeting them in the Points P and p. In like Manner upon all the Tangents of the Curve let Perpendiculars be drawn from the given Point S, and a Curve will be conſtructed paſſing through all the Interſections of the Tangents and Perpendiculars. The Elementary Triangle of this Pnp will be ſimilar to the Triangle Lol, which therefore will be given from the given Curve BlL. For becauſe of equal Angles SnP, PnL, and the

Fig. 15.

right Angles Spn, SPL, the Triangles Spn, PnL, will be equi-angular, and therefore $Pn \,.\, pn :: Ln \,.\, Sn :: Lo \,.\, lo$. Likewiſe becauſe of equal Angles Pnp, SnL, Lol, the Triangles Pnp, SnL, Lol, will be ſimilar. Since therefore there is the ſame Ratio of Ll to lo, as of Pp to pn, and SL to SP; it is plain that the Ratio of Ll to lo being given, and the right Line SL, the Ratio of Pp to pn will be given, and the right Line SP, and therefore the Curve DPp. And by the ſame Method a third may be conſtructed from DP, and from this a fourth; and by proceeding thus an infinite Series of Curves may be derived, all which from one that is known will become known. Now Fig. 10. if LN and ln are erected perpendicularly upon the Radii Sl, Sl, meeting one another in n; and if through all the Points of perpendicular Concourſe that are alike defined, a Curve EN is deſcribed: That will be the very Curve from whence BL may be deduced, by the ſame Method as we conſtructed DP from BL. In like Manner another Curve may be conſtructed from EN, and on this Side likewiſe an infinite Series of Curves may be conſtructed.

Sect. 2.] But of all the Curves produced in this Manner, the moſt ſimple will be, in which Ll is to Lo in the Ratio of ſome Power of the Radius; ſo that if a be a given Quantity, and r denotes the Radius of the Curve, and n any Number whatever; it may be as Ll to lo ſo a^n to r^n, which will be their general Equation. But all theſe will have an Apſid, when $r = a$, becauſe in that caſe $Ll = lo$. To inveſtigate the Equation of the Curve DP; ſince in BL it is, as Ll to lo, ſo is a^n to r^n, ſo is r to $SP = \frac{r^{n+1}}{a^n}$, ſo is $a^{\frac{n}{n+1}} \times SP^{\frac{1}{n+1}}$ to SP, ſo is $a^{\frac{n}{n+1}}$ to $SP^{\frac{n}{n+1}}$, ſo is Pp to pn. Therefore if $\dot{s}$ repreſents the Moment of the Curve, $\dot{y}$ the circular Arch deſcrib'd by the Radius from the Center S, and r the correſponding Radius; whatever the Curve be whoſe Equation is ſought, the Equation of the Curve BL will be $\dot{s} \,.\, \dot{y} :: a^n \,.\, r^n$. But the Equation of the Curve DP is $\dot{s} \,.\, \dot{y} :: a^{\frac{n}{n+1}} \,.\, r^{\frac{n}{n+1}}$. And the Angle PSp will be to the Angle LSl, as $\frac{pn}{SP}$ is to $\frac{lo}{SL}$, or as $\frac{Pn}{Sp}$ is to $\frac{L\dot{o}}{SL}$, or as $\frac{\dot{x}}{x}$ to $\frac{\dot{r}}{r}$, if $SP = x$, and $SL = r$; that is (becauſe $\dot{x} = \frac{r^{n+1}}{a^n}$) as $\frac{n+1}{r}\dot{r}$ is to $\frac{\dot{r}}{r}$, or as $n + 1$ to 1. Hence BSP is to BSL

as $n+1$ to 1; whence the Curve BP may be drawn more eaſily, without the Aſſiſtance of the Tangents. If the Angle BSP to BSL is taken in the Ratio of $n+1$ to 1, and a Perpendicular is let fall from L upon SP, the Meeting of the Perpendicular with SP will be in the Curve BP, which was deſcribed before by the Help of the Tangents. Fig. 16.

Sect. 3.] We have ſhewn how from one, an infinite Series of Curves may be deduced; I ſhall now go on to demonſtrate, how the Lengths of each may be known, from the Lengths of that and another being given. Since the Angle $SPp = SLl$, and LSl is to PSp as 1 to $n+1$; Ll will be to Pp as SL to $\overline{n+1}\ SP$; or (becauſe of $SL . SP :: Ll . lo$,) as Ll to $\overline{n+1}\ lo$; and therefore $Pp = \overline{n+1}\ lo$. But $lo = ln - on = ln - Ln + Nn$. Therefore $Pp = \overline{n+1} \times \overline{ln - LN + Nn}$. But $ln - Ln$ is the Moment of the right Line LN perpendicular to SL; Pp is the Moment of the Curve Bp; and Nn is the Moment of the Curve BN. And ſince BP, BN, BL, vaniſh together in B, they will be in the Ratio of their Moments, and therefore $BP = \overline{n+1} \times \overline{BN + LN}$. Whence the Curve BP is to the Sum or Difference of the laſt Curve but one in the Series, and its Tangent intercepted by the intermediate Curve, as $n+1$ to n; or, putting m for the Index of the Equation of the Curve BP, (becauſe $m = \frac{n}{n+1}$) as 1 to $1 - m$. Fig. 16.

Hence firſt, in the infinite Series of Curves above deſcribed, if the Lengths of two of the neareſt are given, the Lengths of all will be given. For the Meaſure of every one depends always on the Meaſure of the laſt but one in the Series, and therefore one Pair will ſuffice for meaſuring all. If one Curve is commenſurable to right Lines, or incommenſurable, half the intire Series will be commenſurable to right Lines, or incommenſurable. Hence ſecondly, altho' the Curves BP and BN ſhould be incommenſurable to right Lines, yet the Difference of the Curve BP from $n+1$ Part of the Curve BN, would be equal to an aſſignable right Line. Thirdly, if the Curve paſſes through S, the right Line LN vaniſhing in S, it will be $BPS = \frac{BNS}{1-m}$.

Sect. 4.] Of all the Curves about which we have treated, whoſe Property is $\dot{s} . \dot{y} :: a^n . r^n$; the Circle is the moſt remarkable, S being in the Circumference whoſe Equation is $\dot{s} . \dot{y} :: a . r$, as is evident from the Similitude of the Triangles Lol, BLS. Therefore $n = 1$, and conſequently $m = \frac{n}{n+1} = \frac{1}{2}$; and the Equation of the Curve BP will be $\dot{s} . \dot{y} :: a^{\frac{1}{2}} . r^{\frac{1}{2}}$, which is the very Equation of the Epicycloid deſcribed by the Revolution of a Circle upon a Baſe equal to itſelf, to the Point where the deſcribing Point touches the Baſe; which Mr. *Paſchal* calls Mr. *Roberval's Snail*, and which Mr. *de la Hire* conſiders as a Conchoid with a circular Baſe, in the Memoirs Fig. 17.

Memoirs of the Academy of *Paris*, *An.* 1708. All the Perpendiculars LN, ln, concur in the Point B, and therefore $BN = 0$. Whence $BP = \frac{BN+NL}{1-m} + 2BL$. Therefore the whole Curve $BPS = 2BS$, or the Length of the Epicycloid is always double to the Chord of the correſponding Arch in the Circle. *Secondly*, From the Epicycloid let the Curve $B\Pi S$ be deſcribed, in the ſame Manner as we deſcribed the Epicycloid from the Circle. In this Caſe $n = \frac{1}{2}$, and $m = \frac{n}{n+1} = \frac{\frac{1}{2}}{\frac{1}{2}+1} = \frac{1}{3}$, and therefore the Equation of the Curve $B\Pi S$ will be $\dot{s} . \dot{y} :: a^{\frac{1}{3}} . r^{\frac{1}{3}}$. The Length of the Curve will be $\frac{BL+LP}{1-m} = \frac{3}{2} \times \overline{BL+LP} = \frac{3}{2} \times \overline{BL} + \overline{LG}$, and therefore $B\Pi$ is ſeſcuple the Sum of the circular Arch and its right Sine. Now if we take $CD = BD$, and with Radius SD and Center S deſcribe a Circle meeting the right Line SP in H, and HK is made perpendicular to BS; becauſe $DH = \frac{2}{3} BL$, it will be $B\Pi = DH + HK$. Hence the Arches $B\Pi$ are neither commenſurable to right Lines nor to circular Arches, yet the Difference of the Arches $B\Pi$ and DH is the right Line HK. The Line LG vaniſhes in the Point S, and therefore $B\Pi S$ is $= \frac{3}{2} BLS$; whence the whole Curve is ſeſcuple of the Semicircle. Yet no Part of this aſſignable Curve can be commenſurable to the whole, nor is the intire Curve diviſible in any given Ratio, ſo that the Portions may have an aſſignable Ratio to one another or to the whole. If this Curve could be divided Geometrically in any given Ratio, the Quadrature of the Circle would be compleated. For Inſtance, if it were $B\Pi$ to $B\Pi S$, as 1 to m, and BL to BLS as 1 to n, it would be $B\Pi = \frac{B\Pi S}{m} = \frac{3BLS}{2m} = \frac{3nBL}{2m} = \frac{3}{2} \times \overline{BL+LG}$. Whence it would be $BL = \frac{mLG}{n-m}$ and $BLS = \frac{nm}{n-m} LG$. *Thirdly*, by the Method already explain'd, from $B\Pi S$ let the Curve BR be conſtructed; and becauſe $n = \frac{1}{3}$, it will be $m = \frac{n}{n+1} = \frac{1}{4}$, and the Equation of the Curve BR will be $\dot{s} . \dot{y} :: a^{\frac{1}{4}} . r^{\frac{1}{4}}$. Hence the Length of the Curve will be $\frac{4}{3} \times \overline{2BL + P\Pi}$, and the whole Length of the Curve BRS is $\frac{8}{3}$ of the Diameter SB. If the Conſtructions of theſe Curves are continued, there will ariſe ſuch a Series of Equations as this following, which is eaſily continued at Pleaſure.

The Equation of the Circle. 1. $\dot{s} . \dot{y} :: a . r$.

Of the Epicycloid. 2. $\dot{s} . \dot{y} :: a^{\frac{1}{2}} . r^{\frac{1}{2}}$.

Of the Second. 3. $\dot{s} . \dot{y} :: a^{\frac{1}{3}} . r^{\frac{1}{3}}$.

Of the Third. 4. $\dot{s} . \dot{y} :: a^{\frac{1}{4}} . r^{\frac{1}{4}}$.

Of any. 5. $\dot{s} . \dot{y} :: a^{\frac{1}{n}} . r^{\frac{1}{n}}$.

Here it may be obſerved in general, that all thoſe are capable of perfect Rectification, the Denominators of whoſe Indices are even Numbers; and ſince every one to that before it is as 1 to $1 - m$, it will appear to any one that conſiders it, that the Length of any Curve will be $\frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m} \times \frac{1-6m}{1-7m}$, *&c.* $\times$ S B, continuing the Series till the Fraction is reduced to nothing. Now if the Denominator of the Index be an odd Number, the Curves will be incapable of perfect Rectification, and any of their Arches will be incommenſurable to each other, to the Wholes, to any right Lines, and circular Arches: Yet all may be expreſſed by circular Arches and right Lines. But the total Length of any Curve will be to the Semicircle, as $\frac{1}{1-m} \times \frac{1-2m}{1-3m} \times \frac{1-4m}{1-5m}$, *&c.* to Unity. *Laſtly*, if the little Area, deſcribed by a Body revolving in any one of theſe, be taken as conſtant, that is, if $r\dot{y} = 1$, the Subtenſe of the Angle of Contact, to which (becauſe of the Time being given if the Area is given) the Centripetal Force tending to S will always be proportional, will be reciprocally as the Power of the Diſtance whoſe Index is $2m + 3$. And this is no contemptible Privilege of theſe Curves, that in all of them the Centripetal Force tending to S, is as ſome Dignity of the Diſtance reciprocally; which is the moſt ſimple, and moſt uſeful Law of Centripetal Forces, in ſearching into Nature.

Sect. 5.] Of all the Curves in which $\dot{s} . \dot{y} :: a^{n} . r^{n}$, the right Line itſelf is next to be conſider'd, (which is indeed properly called a Curve) the Point S being without that right Line. In this Line becauſe of ſimilar Triangles P *p n*, P B S, if B S = *a*, and S P = *r*, it will be $\dot{s} . \dot{y} :: r . a$. By the direct Method nothing can be conſtructed from the right Line but the Point B; but by the inverſe Method, or from the Concourſe of the Perpendiculars P L, *p l*, a Curve may be conſtructed, whoſe Fig. 18.

whoſe Index will be equal to $\frac{m}{1-m}$, if m be the Index of the Curve B P. For if the Index of the Curve B L is n, then it will be $m = \frac{n}{n+1}$, and therefore $n = \frac{m}{1-m}$. Whence in this Caſe, ſince $m = -1$, it will be $n = \frac{-1}{2}$, and the Equation of the Curve B L will be $\dot{s} . \dot{y} :: r^{\frac{1}{2}} . a^{\frac{1}{2}}$, which is an Equation of the Parabola in reſpect of its Focus. From this conſtruct another, by making the Angle L S N = L S B, and raiſing L N perpendicular to S L, meeting S N in N. Now becauſe $m = \frac{-1}{2}$ it will be $n = \frac{-1}{3}$ and the Equation of the Curve will be $\dot{s} . \dot{y} :: r^{\frac{1}{3}} . a^{\frac{1}{3}}$, and $\mathrm{B\,P} = \frac{\mathrm{B\,N} - \mathrm{L\,N}}{1-m} = \frac{1}{2}\overline{\mathrm{B\,N} - \mathrm{L\,N}}$, and therefore $\mathrm{B\,N} = 2\,\mathrm{B\,P} + \mathrm{L\,N}$; and therefore this Curve is rectifiable. If the Series is continued, the Equations will ariſe as before in this Order.

Equation of the right Line, $\dot{s} . \dot{y} :: r . a$.

Of the Parabola, $\dot{s} . \dot{y} :: r^{\frac{1}{2}} . a^{\frac{1}{2}}$.

Of the Second, $\dot{s} . \dot{y} :: r^{\frac{1}{3}} . a^{\frac{1}{3}}$.

Of the Third, $\dot{s} . \dot{y} :: r^{\frac{1}{4}} . a^{\frac{1}{4}}$.

Of any, $\dot{s} . \dot{y} :: r^{\frac{1}{n}} . a^{\frac{1}{n}}$.

In this Series the firſt are the right Line and the Parabola, whence it appears that half this Series, as well as the former, are commenſurable to right Lines; and the other half may be exhibited by right Lines and Arches of a Parabola. In all theſe the Centripetal Force at S is reciprocally as that Power of the Diſtance, the Index of which is $3 - 2m$; and therefore is always between the duplicate and triplicate Ratio of the Diſtance reciprocally.

Sect. 6.] The Equation of the Equilateral Hyperbola at the Center is $\dot{s} . \dot{y} :: r^{2} . a^{2}$. From which by the direct Method ſuch a Series may be deduced,

1. $\dot{s} . \dot{y} :: r^{2} . a^{2}$.

2. $\dot{s} . \dot{y} :: a^{2} . r^{2}$.

3. $\dot{s} . \dot{y} :: a^{\frac{2}{3}} . r^{\frac{2}{3}}$.

4. $\dot{s} . \dot{y} :: a^{\frac{2}{5}} . r^{\frac{2}{5}}$.

5. $\dot{s} . \dot{y} :: a^{\frac{2}{2n-1}} . r^{\frac{2}{2n-1}}$.

Of theſe Curves, thoſe the Denominators of whoſe Indices are in this Progreſſion, — 1, 3, 7, 11, *&c.* may be exhibited in right Lines and Arches of the Hyperbola; the reſt in right Lines and Arches of the Curve, whoſe Equation to the Axis *A B*, (making *x* the Abſciſs, and *y* the Ordinate) is $\overline{xx+yy}|^2 = a^2 x^2 - a^2 y^2$, and which is conſtructed (*See Fig.* 17.) by biſecting the Angle *B S L*, and taking *S N* a mean Proportional between *S B* and *S L*.

The Curves which may be conſtructed from the Hyperbola in the inverſe Method, proceed as in this Series.

Of the Hyperbola, 1. $\dot{s} . \dot{y} :: r^2 . a^2$.

3. $\dot{s} . \dot{y} :: r^{\frac{2}{3}} . a^{\frac{2}{3}}$.

3. $\dot{s} . \dot{y} :: r^{\frac{2}{5}} . a^{\frac{2}{5}}$.

where the Curves, the Denominators of whoſe Indices are in the Progreſſion 1, 5, 9, 13, *&c.* may be expreſs'd in right Lines and Hyperbolic Arches; but the others in right Lines and the Arches of the Curve juſt now explain'd.

If other Curves were deſired which ſhould exhibit other Series, this may be done very eaſily by Means either of a Circle or of a right Line. For by one of them all the Curves may be conſtructed, in which $\dot{s} . \dot{y} :: a^n . r^n$; by taking (if the Problem is to be ſolved by Means of the Circle) *B R S* to *B S L* as 1 to *n*, and *S N* in $SR = a^{\frac{n-1}{n}} \times SL^{\frac{1}{n}}$. For the Equation of the Curve drawn through all the Points *N*, will be $\dot{s} . \dot{y} :: a^n . r^n$. In like Manner Curves may be conſtructed by Means of a right Line, whoſe Equation will be $\dot{s} . \dot{y} :: r^n . a^n$. Fig. 19.

We have exhibited two infinite Series of Curves, that are commenſurable to right Lines; we have demonſtrated another to be commenſurable to circular Arches, another to Parabolical, another to Hyperbolical together with right Lines; but thoſe ſeem reducible to the Meaſure of right Lines by infinite Art only, as they are expreſſed in right Lines only by an infinite Equation.

XIII. Whereas the great *Newton* has not extended his Method for deſcribing Curves, to thoſe of the third Order which are without a double Point, or to thoſe of an higher Order deſtitute of a *punctum multiplex*; and pronounces their Deſcription to be reckoned among the more difficult Problems of Geometry; I hope the following Method will not be unacceptable to Geometricians, by which Geometrical Curves of any Order are conſtructed, (by the Help only of given Angles and Right Lines,) though they may be without a *punctum duplex* or *multiplex*.

A New Method of deſcribing all Kinds of Curves, *by Mr.* C. Maclaurin, n. 359. p. 939.

1. Lines of the firſt Order are only right Lines themſelves, which can meet one another only in one Point. Lines of the ſecond Order are

Conic Sections, which cannot be cut by a right Line in more than two Points. Now all theſe may be thus conſtructed, according to Lem. 21. Lib. 1. of *Newton*'s *Principia*. Let two given Angles M C R and L S N Fig. 20. move about two given Points C and S, ſo that Q the Concourſe of the Legs C M, S L, may always deſcribe the indefinite right Line A E given in Poſition; then the Concourſe of the other Legs C R and S N in the Point P, will deſcribe a Line of the ſecond Order, or a Conic Section.

Fig. 21. 2. Let the Angle M C R (as before) move about the given Point C; and the given Angle L N Q by its Angular Point N always run over the given right Line A E, ſo that the Leg N Q may always paſs through the given Point S. Firſt, if the Concourſe of the Legs C R and S N, and alſo the Point Q, be drawn through the infinite Line A B, the Concourſe of the Legs C M and N L will deſcribe a Curve-line of the third Order, having a double Point in C. Secondly, the reſt remaining as be- Fig. 22. fore, if the Concourſe of the Legs C M and N L is drawn through the indefinite right Line A B; the Concourſe of the Legs C R and S N in P, will deſcribe a Curve of the third Order, having a double Point in S.

Fig. 23. *Example of Caſe* 1. Let the Angles M C R and L N S be right Angles, and A E, D B, C S, be parallel; alſo let S A and S D be perpendicular to A E and D B reſpectively, and let S D = 2 S A. Theſe things ſuppoſed, if S D be leſs than the Line C S, a Curve deſcribed according to the Rule of the firſt Caſe, will be a Parabola with a Node and an Oval, of the 68th Species of *Newton*'s Curves. Now if S D = C S, the Oval vaniſhes, and the Node becomes a Cuſpis, and the Curve ſo deſcribed will be *Neil*'s or the ſemicubical Parabola. But if S D be greater than C S, the Curve will be a Parabola with a Point and Campaniform, of the 69th Species.

Fig. 24. 3. Let the given Angles R M T and K N L move in ſuch Manner, that the Points M and N may run over the indefinite Lines B M and D N reſpectively, and let the Legs R M and K N always paſs through the given Points C and S. Firſt, if the Concourſe Q of the Legs M T and N L is drawn through the indefinite right Line A Q; then the Concourſe of the Legs M R and N R in P will deſcribe a Line of the fourth Order, having two double Points, one in C and the other in S. But ſecondly, Fig. 25. if the Concourſe of the Legs M R and N K be drawn through the indefinite right Line A Q; then the Concourſe of the Legs M T and N L will deſcribe a Line of the fourth Order, which will have no double Point.

Fig. 24. 4. Now in the firſt Caſe of this Conſtruction, if the right Lines C M R and S N K coincide together with C S; then the Points C and S become Fig. 26. ſimple, and the Curve will be of the third Order without a double Point. For Example, let the right Lines B M, A Q, D N be parallel to one another, and all perpendicular to C S. Alſo let the Angles R M T and K N L be right; and if a Curve be deſcribed according to the Rule of the firſt Caſe, the Legs C M R and S N K will coincide with S C;

and by this Conſtruction may be deſcribed the Curves of *Newton*, 10, 11, 20, 21, 40, according to the various Poſitions of the Points C and S in reſpect of the three right Lines B M, A Q, D N; but all theſe Species will be without a double Point.

Fig. 27. 5. But Lines of the fourth Order, which have a treble Point, may be thus conſtructed. Let there be three right Lines A Q, B N, D M, given in Poſition. Alſo let the Angles Q C T, S N M, N M L, be given and invariable. Let the Points N and M run through the right Lines B N and D M, ſo that the Leg N Q may always paſs through the given Point S. Let Q C T ſo revolve about C, that the Concourſe of the Legs C K and S N may run through a third right Line A Q. Then the Concourſe of the Legs C T and M L will deſcribe a Line of the fourth Order, having a triple Point in C.

6. I have ſhewn how Lines of the fourth Order may be deſcribed, which have a triple Point or two double Points. Others having only one double Point may be thus conveniently deſcribed. Let there be three Lines A Q, B N, D M, given in Poſition as before; alſo let the Angles S N K, S M L, R C T be given. Fig. 28. Let the Points N, M, S, be always in the ſame right Line. Let the Points N, M, move as before through the right Lines B N, D M; if the Concourſe of the Legs C R, N K, is drawn through the indefinite right Line A Q, then the Concourſe of the Legs C T, M L, will deſcribe a Line of the fourth Order, having one double Point in C. Now theſe two laſt Propoſitions ſupply us with new Methods for deſcribing Lines of the third Order, as well thoſe that have double Points, as thoſe that have none. But in this ſhort Specimen of our Method theſe muſt be omitted.

Fig. 29 7. Let the Angles and right Lines remain, as in *Prop.* 3. and let the Concourſe of the right Lines M T, N K, now be drawn through the indefinite right Line A Q; and the Concourſe of the Legs M R and N L will deſcribe a Line of the fifth Order, having a quadruple Point in S. I have alſo other Methods for deſcribing Curves of the fifth Order, which have a double or triple Point, or two double Points, or none but ſimple Points, but theſe may ſuffice to ſhew the Simplicity and Univerſality of the Method. But it muſt be obſerved, that in particular and ſimpler Circumſtances of the Angles and right Lines, ſometimes a Line will paſs into a Curve of an Order inferior to that which is explain'd in the Propoſition. Nay, all the Propoſitions ſupply particular Methods of deſcribing ſome Curves of every inferior Order.

Fig. 30. 8. *General Propoſition.* Let right Lines be taken at Pleaſure any where poſited in the ſame Plain, of which let the Number be *n*; as B N, E R, F T, alſo let other right Lines be taken at Pleaſure, as D M, G L, H K, *&c.* of which let the Number be *m*. Let the Angles C N R, N R T, R T Q, *&c.* alſo the Angles S M L, M L K, L K Q, *&c.* be invariable, whilſt the Angular Points N, R, T, M, L, K, perambulate the indefinite right Lines B N, E R, F T, D M, G L, H K; let the Concourſe of the

Legs T Q and K Q be drawn thro' the indefinite right Line A Q; to find the Order of the Curve which ſhall be deſcribed by the Concourſe of the Leg S M with any one of the right Lines C N, N R, R T, T Q, *&c.* for Inſtance, with the Line R T.

In the Series of the right Lines C N, N R, R T, T Q, *&c.* let s denote the Number of the right Line R T, by the Concourſe of which with S M the Curve is to be deſcribed, from the Line C N incluſively; which in this Caſe is the third, or $n = 3$. Then will the Curve be of an Order which is expreſs'd by the Number $sm + s + n + 1$. Whence in the Caſe denoted by the Figure, ſince $s = m = n = 3$, the Curve will be of the ſixteenth Order.

In theſe Deſcriptions we have only poſtulated, that right Lines and Angles ſhould be given. But generally the more complicated Curves are more eaſily deſcribed by the Help of ſimpler Curves. And I have inveſtigated Propoſitions of this Kind, not leſs univerſal than theſe. But I omit theſe at preſent, with the Demonſtrations of theſe, becauſe they would be too prolix, tho' perhaps I may publiſh them hereafter.

The Doctrine of Combinations and Alternations, by Major Ed. Thornicroft, n. 299. p. 1961.

XIV. In order to underſtand what follows, it muſt be obſerved, *1ſt*, That as in the Notation of Powers, $a\,a\,a\,a\,b\,b\,b\,c\,c$ is deſigned by $a^4 b^3 c^2$, and univerſally p times the Poſition of a, q times the Poſition of b, r times the Poſition of c, by $a^p b^q c^r$, ſo in Things expoſed likewiſe; (unleſs where 'tis propoſed they ſhould be all different) which Indices, as they have here no Relation to Powers, but expreſs only the Occurrences of thoſe Things to which they reſpectively belong; I therefore call Indices of Occurrences.

2dly, That as often as I ſhall hereafter mention the Combination or Alternations of the p^s q^s r^s or s^s, (which, conſidered by themſelves, are capable of no Variation) I mean of thoſe Things whoſe Indices they are.

3dly, That m is generally put for the whole Number of Things expoſed, whether all different or not, *i. e.* equal to the Sum of their Indices; and n, for ſuch a Number of them, as each Combination and Alternation muſt conſiſt of; (unleſs preſuppoſed equal) which explains what is hereafter meant by the Combinations and Alternations of m Things taken n and n; or of m Things taken m and m; and the like Expreſſion, by whatever Symbols the Number of Things, out of which the Combinations and Alternations are to be made, or of which they are to conſiſt, may be deſign'd.

Lemma 1.] If in a right Line, at any Diſtances, be placed any Number of Things $a\,b\,c\,d$, *&c.* the Number of the Intervals $a\,b$, $b\,c$, $c\,d$, *&c.* terminated each by two adjacent Things, is one leſs than the Number of Things.

For, whereas every Interval is terminated by two adjacent Things, if to any Number of Things, be added one Thing more, one Interval only is thereby added. *Q. E. D.*

Lemma 2.] The Number of the Alternations of m Things $a\,b\,c\,d$, *&c.* different from each other, taken m and m, is m times the Number of the Alternations of $m - 1$ Things $a\,b\,c$, taken $m - 1$ and $m - 1$.

For (by *Lem.* 1*ſt.*) the laſt Letter *d*, beſides the Poſition it hath, may have $m-2$ Poſitions, *viz.* in the Intervals which are between $m-1$ Things *a b c*; but it may alſo have one more, for it may be put firſt of all, it may therefore have *m* Poſitions; and thoſe in all the different Orders whereof $m-1$ Things are capable; which being all the poſſible Poſitions of *d*, in all the Varieties of *a b c*, is all the Variety whereof the whole Number of Things expoſed *a b c d*, &c. is capable. *Q. E. D.*

Lemma 3.] The Number of the Alternations of *m* Things *a*, *b*, *c*, *d*, &*c.* different each from other, taken *m* and *m*, is equal to $m \times m-1 \times m-2 \times m-3 \times m-4$, &*c.* continued to *m* Places.

For let $m\,O$ expreſs the Number of the Alternations of *m* Things different from each other; $\overline{m-1}\,O$, of $m-1$ Things, and the like.

'Tis evident that if $m=1$, it will be $m\,O=m$; for there can be but one Order of one Thing.

And if *m* be greater than Unity, then it will be (by *Lem.* 2.) $m\,O = m \times \overline{m-1}\,O = m \times m-1 \times \overline{m-2}\,O = m \times m-1 \times m-2 \times \overline{m-3}\,O =$, &*c.* till we have an Equation conſiſting of *m* Places; *i. e.* $= m \times m-1 \times m-2 \times m-3 \times$ &*c.* continued to *m* Places. *Q. E. D.*

Lemma 4.] If $m\,\omega$ expreſs the Number of the Alternations of *m* Things $a^p\ b^p\ c^p\ d^q\ e^q\ f^r$, &*c.* taken *m* and *m*, and α the Number of *p*'s, β the Number of *q*'s, γ the Number of *r*'s, it will be

$$m\,\omega = \frac{m \times \overline{m-1} \times \overline{m-2} \times \overline{m-3} \times \overline{m-4} \times \overline{m-5} \times \&c. \text{ continued to } m \text{ Places.}}{\overline{p \times \overline{p-1} \times \overline{p-2} \times \&c.}^{\,\alpha} \times \overline{q \times \overline{q-1} \times \&c}^{\,\beta} \times \overline{r \times \overline{r-1} \times \&c.}^{\,\gamma}}$$

each Series continued to *p*, *q*, *r*, &*c.* Places reſpectively.

For the Number of the Alternations of any Number of Things, however divided into Parts, is produc'd by a continual Multiplication of the Alternations of thoſe Things among themſelves reſpectively, which compoſe each Part, into the Number of their Alternations one amongſt the other; *i. e.* in the preſent Caſe (the ſeveral Occurrences being ſuppoſed to compoſe the ſeveral Parts, and conſequently the Number of the Alternations of the Things compoſing each Part equal to Unity) $m\,\omega =$ to the Number of the Alternations of the Things compoſing the Parts one amongſt the other; but the Number of their Alternations one amongſt the other, is the ſame in this Caſe, as if the Things expoſed, being all different, were divided into the ſame Parts; for the Things which compoſe each Part in both Caſes, are different from the reſt of the Things expoſed, *i. e.* by *Lem.* 3.

$$m\,\omega = \frac{m \times \overline{m-1} \times \overline{m-2} \times \overline{m-3} \times \overline{m-4} \times \overline{m-5} \times \&c. \text{ continued to } m \text{ Places.}}{\overline{p \times \overline{p-1} \times \overline{p-2} \times \&c.}\big|^{\alpha} \times \overline{q \times \overline{q-1} \times \&c.}\big|^{\beta} \times \overline{r \times \overline{r-1} \times \&c.}\big|^{\gamma}}$$

each Series continued to *p*, *q*, *r*, Places reſpectively. *Q. E. D.*

Lemma 5.] The Number of the Combinations of *m* Things *a b c d*, &*c.* different from each other, taken *n* and *n*, is equal to

$$\frac{m \times \overline{m-1} \times \overline{m-2} \times \overline{m-3} \times \&c.}{n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3} \times \&c.}$$ each Series continued to *n* Places.

For if the Things expos'd be divided in two Parts, *viz.* in the *Ratio* of n and $m-n$, 'tis evident that their different Combinations taken n and n, are produced by the Alternations of the Things compoſing the Parts one amongſt the other: And therefore the Number of thoſe = to the Number of theſe = to the Number of the Alternations of m Things taken m and m, the Indices of whoſe Occurrences are n and $m-n=\frac{m\times m-1\times n-2\times m-3\times \&c.\ \text{continued to } m \text{ Places.}}{n\times n-1\times \&c.\times m-n\times m-n-1\times \&c.}$ each Series continued to n and $m-n$ Places reſpectively (by *Lem.* 4.) *i. e.* becauſe $n+m-n=m=\frac{m\times m-1\times m-2\times m-3\times \&c.}{n\times n-1\times n-2\times n-3\times \&c.}$ each Series continued to n Places.

Q. E. D.

But the Number of the Alternations in every Combination is $=n\times n-1\times n-2\times n-3\times \&c.$ continued to n Places, (by *Lem.* 3.) therefore

Lemma 6.] The Number of the Alternations of m Things $a\ b\ c\ d$, &c. different each from other, taken n and n, is $=m\times m-1\times m-2\times m-3\times \&c.$ continued to n Places. *Q. E. D.*

Scholium.] Since in the Things expoſed the ſame Things may occur more than once, and alſo n be leſs than m, the Indices of the Occurrences, which are in ſome of the Combinations of m Things taken n and n, may differ from thoſe which are in others; but thoſe Combinations, the Indices of whoſe Occurrences are the ſame, are ſaid to be in the ſame Form: Therefore whereas n is equal to the Sum of the Indices which are in each Combination taken n and n, if n be expreſſed by all the different Combinations of ſuch Indices only (being integer Numbers) whereof no one may exceed the higheſt Index of the Things expoſed, and being more than one in a Combination, are each of them, which are in the ſame Combination, comprehended in a diſtinct Index thereof; theſe Expreſſions of n will neceſſarily be the ſeveral Forms of the Combinations taken n and n, whereof m Things are capable: Whence is derived a general Theorem for finding the Combinations and Alternations of m Things taken n and n univerſally: *i. e.* Whether m conſiſt of Things all different or not, and whether n be equal to, or leſs than m.

Theorem.] If n be expreſſed, according to all the different Forms of Combination which the Things expoſed are capable of,

$$\text{and}\left\{\begin{array}{l} p=\text{the higheſt Index}\\ q=\text{the next higheſt}\\ r=\text{the next higheſt}\\ ſ=\text{the next higheſt}\\ \quad\&c. \end{array}\right. \left\{\begin{array}{l} \alpha=\text{the Number of } p\text{'s}\\ \beta=\text{the Number of } q\text{'s}\\ \gamma=\text{the Number of } r\text{'s}\\ \delta=\text{the Number of } ſ\text{'s} \end{array}\right\}\begin{array}{c}\text{In every Form}\\ \text{of Combina-}\\ \text{tion.}\end{array}$$

$$\left\{\begin{array}{l} A=\text{the Number of all Indices not leſs than } p\\ B=\text{the Number of all Indices not leſs than } q\\ C=\text{the Number of all Indices not leſs than } r\\ D=\text{the Number of all Indices not leſs than } ſ\\ \quad\&c. \end{array}\right\}\begin{array}{c}\text{Which are in the}\\ \text{Things expoſed.}\end{array}$$

and $b=a+\beta$, $c=b+\gamma$, $d=c+\delta$, &c. I ſay

I ſay the Number of the Combinations of m Things taken n, and n in any one Form of Combination, ſhall be $\frac{A\times\overline{A-1}\times\overline{A-2}}{\alpha\times\overline{\alpha-1}\times\overline{\alpha-2}}$ &c.

$$\times\frac{\overline{B-\alpha}\times\overline{B-\alpha-1}}{\beta\times\overline{\beta-1}}\times\text{\&c.}\frac{\overline{C-b}\times\overline{C-b-1}}{\gamma\times\overline{\gamma-1}}\times\text{\&c.}\times\frac{\overline{D-c}\times\overline{D-c-1}}{\delta\times\overline{\delta-1}}\text{\&c.}$$

continued to ſo many Terms as there are different Indices in the Form of Combination, and each Term to α, β, γ, δ, &c. Places reſpectively, and this Number multiplied into

$$\frac{\times\overline{n-1}\times\overline{n-2}\times\overline{n-3}\times\overline{n-4}\times\overline{n-5}\times\overline{n-6}\ \text{\&c. continued to } n \text{ Places.}}{\overline{p\times\overline{p-1}\times\overline{p-2}\times\text{\&c.}}|^{\alpha}\times\overline{q\times\overline{q-1}\times\text{\&c.}}|^{\beta}\times\overline{r\times\overline{r-1}\times\text{\&c.}}|^{\gamma}}\times\text{\&c.}$$

each Series continued to p q r, &c. Places reſpectively, ſhall be the Number of their Alternations.

But the Sum of all the Combinations and Alternations which are in every Form of n, ſhall be the whole Number of Combinations and Alternations of m Things taken n and n.

Demonſtration.] Firſt then 'tis evident, That thoſe Combinations which are in different Forms, differ from each other.

Again, 'tis evident, that the Combinations of m Things, as a^p b^p c^p d^p e^q f^q g^q h^r i^r, &c. (the Indices ſimply conſidered) taken n and n, in a Form wherein are p's q's r's, ſhall be equal to the Number of the Combinations of the p's, which are in the Things expoſed, taken α and α, multiplied into the Number of the Combinations of the q's taken β and β, multiplied into the Number of the Combinations of the r's taken γ and γ.

But becauſe p and all leſſer Indices are comprehended in every Index, which is greater than themſelves; therefore is $A =$ to the Number of p's, which are in the Things expoſed, and for the ſame Reaſon would $B =$ the Number of the q's, and C the Number of r, : But the Number of the p's, which are in every Form of Combination, is $= \alpha$; therefore is $B-\alpha =$ to the Number of q's; alſo becauſe the Number of p's and q's together, which are in every Form of Combination, wherein there are q's, is $= \alpha + \beta = b$; therefore is $C-b =$ to the Number of r's, and ſo on, how many ſoever were the different Indices in any Form of Combination.

But (by *Lemma* 5.) the Number of the Combinations of the p's, which are in the Things expoſed, whoſe Number is A, taken α and α, is $=\frac{A\times\overline{A-1}\times\overline{A-2}}{\alpha\times\overline{\alpha-1}\times\overline{\alpha-2}}$, &c. continued to α Places, and the Number of the Combinations of the q's, whoſe Number is $B-\alpha$, taken β and β, is $=\frac{\overline{B-\alpha}\times\overline{B-\alpha-1}}{\beta\times\overline{\beta-1}}\ \frac{\times\overline{B-\alpha-2}}{\times\overline{\beta-2}}$, &c. continued to β Places, and the Number of the Combinations of the r's, whoſe Number is $C-b$, taken γ and γ, is $=\frac{\overline{C-b}\times\overline{C-b-1}}{\gamma\times\overline{\gamma-1}}$, &c. continued to γ Places. *Q. E. D.*

But every Combination in one and the ſame Form, affords the ſame Number of Alternations: Therefore the Number of Alternations, in any one Form, is ſo many Times the Number of Combinations, as is the Number of Alternations in any one of theſe Combinations.

But (by *Lem.* 4.) the Number of Alternations in any of thoſe Combinations ſhall be

$$\frac{n\times\overline{n-1}\times\overline{n-2}\times\overline{n-3}\times\overline{n-4}\times\overline{n-5}\times\overline{n-6}\times\ \&c.\ \text{continued to } n \text{ Places.}}{\overline{p\times\overline{p-1}\times\overline{p-2}\times\ \&c.}|^{\alpha}\times\overline{q\times\overline{q-2}\times\ \&c.}|^{\beta}\times\overline{r\times\overline{r-1}\times\ \&c.}|^{\gamma}\times}$$ each Series continued to *p q r*, &c. Places reſpectively. *Q. E. D.*

Now to make an Application of this general Rule, to thoſe particular Caſes which have already been conſidered by others, and which are contained in our 3d, 4th, 5th, and 6th *Lemma's*, and by us more generally demonſtrated; I ſay

If $n = m$, there can be but one Form of Combination, and but one Combination in that Form; and therefore the Number of Alternations

$$\frac{m\times\overline{m-1}\times\overline{m-2}\times\overline{m-3}\times\overline{m-4}\times\ \&c.\ \text{continued to } m \text{ Places.}}{\overline{p\times\overline{p-1}\times\ \&c.}|^{\alpha}\times\overline{q\times\overline{q-1}\times\ \&c.}|^{\beta}\times\overline{r\times\ \&c.}|^{\gamma}\times\ \&c.}$$ each Series to *p q r*, &c. Places reſpectively, *i. e.* (if $p = 1$) $= m\times\overline{m-1}\times\overline{m-2}\times\overline{m-3}\times\overline{m-4}\times$ &c. continued to m Places, which are the Caſes of the 4th and 3d *Lemma's*.

But if the Things expoſed are all different, and n be leſs than m, which is the Caſe of the 5th and 6th *Lemma's*, then alſo can there be but one Form of Combination, and it will be $A = m$ and $\alpha = n$, and the whole Number of Combinations $= \dfrac{A\times\overline{A-1}\times\overline{A-2}\times\ \&c.}{\alpha\times\overline{\alpha-1}\times\overline{\alpha-2}\times\ \&c.}$ *i. e.*

$= \dfrac{m\times\overline{m-1}\times\overline{m-2}\times\ \&c.}{n\times\overline{n-1}\times\overline{n-2}\times\ \&c.}$ each Series continued to n Places, and therefore the Number of Alternations $= m\times\overline{m-1}\times\overline{m-2}\times$ &c. continued to n Places.

But fully to illuſtrate this Theorem, which may ſeem ſomewhat too abſtracted, I ſhall ſubjoin one ſhort Example.

Example.] Let the Things expoſed be *a a a b b b c c*, or according to our Way of Notation $a^3\, b^3\, c^2$; 'Tis required to find the Number of their Combinations and Alternations taken 4 and 4.

Then (becauſe in the Things expoſed, there is no one Thing occurs more than thrice, nor more than three Things different from each other) will all the Forms of Combination, which the Things expoſed are capable of, be theſe,

$$\textit{viz.}\left\{\begin{array}{l}3\cdot1\\2\cdot2\\2\cdot1\cdot1\end{array}\right\}\text{Then}$$

In the 1ſt Form will $p = 3$, $q = 1$, $\alpha = 1$, $\beta = 1$, $A = 2$, $B = 3$,
In the 2d Form will $p = 2$, ——, $\alpha = 2$, ——, $A = 3$, ——
In the 3d Form will $p = 2$, $q = 1$, $\alpha = 1$, $\beta = 2$, $A = 3$, $B = 3$.

The Number of Combinations in the 1ſt Form $= \frac{A}{\alpha} \times \frac{B-\alpha}{\beta} = \frac{2}{1} \times \frac{2}{1} = 4$

The Number of Combinations in the 2d Form $= \frac{A \times \overline{A-1}}{\alpha \times \overline{\alpha-1}} = \frac{3 \times 2}{2 \times 1} = 3$

The Number of Combinations in the 3d Form $= \frac{A}{\alpha} \times \frac{\overline{B-\alpha} \times \overline{B-\alpha-1}}{\beta \times \overline{\beta-1}} = \frac{2 \times 1}{2 \times 1} = 3$

And the whole Number of Combinations $= 10$

Alſo the Number of Alternations.

In the 1ſt Form $= 4 \times \frac{n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3}}{\overline{p \times \overline{p-1} \times \overline{p-2}}|^{\alpha} \times q^{\beta}} = 4 \times \frac{4 \times 3 \times 2 \times 1}{\overline{3 \times 2 \times 1}|} 1 \times = 4 \times 4 = 16$

In the 2d Form $= 3 \times \frac{n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3}}{\overline{p \times \overline{p-1}}|^{\alpha}} = 4 \times \frac{4 \times 3 \times 2 \times 1}{\overline{2 \times 1}|^{2}} = 3 \times 6 = 18$

In the 3d Form $= 3 \times \frac{n \times \overline{n-1} \times \overline{n-2} \times \overline{n-3}}{\overline{p \times \overline{p-1}}|^{\alpha} \times q^{\beta}} = 3 \times \frac{4 \times 3 \times 2 \times 1}{\overline{2 \times 1}|^{1} \times 12} = 3 \times 12 = 36$

And the whole Number of Alternations $= 70$

Many are the Properties of this *Theorem* in common with others, as, To find an *Unciæ* of a Multinomial raiſed to any integer Power. To raiſe an infinite Series to an integer Power, though of an interrupted Order, without introducing any Thing immaterial, or which muſt afterwards be expunged, and many others. But then ſo many Terms of the Series muſt be taken in at firſt as ſhall ſerve to the Purpoſes of the intended Approximation, otherwiſe, as often as it ſhall fall ſhort of that, the Operation muſt be begun *de novo*.

Many likewiſe are the Properties peculiar to this *Theorem*, and great Variety of Problems might be framed; and I ſcruple not to ſay, many may occur in Practice, which are ſolvable by this, and no other Method whatever.

Hence may be found the Number of Words whereof the 24 Letters are capable, from one Letter in each Word, to any Number of Letters given.

Hence may be found the Number of all Numbers, to any given Number of Places, which may be produced from any Number of Figures given.

Hence alſo the Compaſs of a Muſical Inſtrument being given, the Time and Number of the Bars, whereof each Tune ſhall conſiſt, the Number of Tunes may be found which that Inſtrument is capable of.

To give an Inſtance of the prodigious Variety that there is in Muſick, I have calculated the Number of Tunes in common Time, conſiſting of eight Bars each, which may be played on an Inſtrument of one Note Compaſs only, and it is this, *viz.* 27584. 270157. 013570. 368586. 999728. 299176. whereas the Changes on 24 Bells is but 620448. 401733. 239439. 360000. which is but

$\frac{1}{444588.\ 604583}$ of the Number of Tunes, and yet Dr. *Wallis* in his *Algebra* demonſtrates, could not be diſpatch'd in 31557. 600000. 000000 Years.

If then the Inſtrument were of as many Notes Compaſs as any Inſtrument now in Uſe, how prodigiouſly muſt the Number of Tunes be encreaſed! the Calculation of which (though much more intricate and operoſe) would be equally attainable by our Theorem.

The Univerſal Solution of Cubic and Biquadratic Equations, as well Analytically as Geometrically and Mechanically: By John Colſon, M.A. & F.R.S. *n.* 309. *p.* 2353.

XV. §. 1. Of the Univerſal Cubic Equation

$$\begin{array}{rl} x^3 = 3px^2 + & 3q \times x + 2r \\ & -3p^2 \quad + p^3 \\ & \qquad\quad -3pq \end{array}$$

The three Roots are

$$x = p + \sqrt[3]{r + \sqrt{r^2 - q^3}} + \sqrt[3]{r - \sqrt{r^2 - q^3}},$$

$$x = p - \frac{1 - \surd -3}{2} \times \sqrt[3]{r + \sqrt{r^2 - q^3}} - \frac{1 + \surd -3}{2} \times \sqrt[3]{r - \sqrt{r^2 - q^3}},$$

$$x = p - \frac{1 + \surd -3}{2} \times \sqrt[3]{r + \sqrt{r^2 - q^3}} - \frac{1 - \surd -3}{2} \times \sqrt[3]{r - \sqrt{r^2 - q^3}}.$$

Or to make the Arithmetical Calculation the more eaſy and ready, we may ſuppoſe $m + \surd n$ to repreſent the Cubic Root of the irrational Binomial $r + \sqrt{r^2 - q^3}$. Then the three Roots of the foregoing Equation will be $x = p + 2m$, and $x = p - m \pm \surd -3n$.

Therefore when any Cubic Equation is given, we muſt make a Compariſon between its Terms, and the ſeveral Terms of the Univerſal Cubic Equation reſpectively, by which Means the Values of p, q, and r will be eaſily found: And when theſe are known, the Roots of the given Equation will thence be known. Of this Solution here follow ſome Examples in Numbers.

1. Let the Root x be propoſed to be found in this Equation, $x^3 = 2x^2 + 3x + 4$. Firſt, as order'd above it will be $3p = 2$, or $p = \frac{2}{3}$. Secondly, $3q - 3p^2 = 3$, that is, $3q - \frac{4}{3} = 3$, or $q = \frac{13}{9}$. Thirdly, $2r + \overline{p^2 - 3q} \times p = 4$, or $2r - \frac{70}{27} = 4$, that is, $r = \frac{89}{27}$; and $r^2 - q^3 = \frac{212}{27}$. Therefore $x = \frac{2}{3} + \sqrt[3]{\frac{89}{27} + \sqrt{\frac{212}{27}}} + \sqrt[3]{\frac{89}{27} - \sqrt{\frac{212}{27}}}$. The other two Roots are impoſſible.

2. In the Equation $x^3 = 12x^2 - 41x + 42$, it will be firſt, $3p = 12$, or $p = 4$. Secondly, $3q - 3p^2 = -41$, or $3q - 48 = -41$, that is, $q = \frac{7}{3}$. Laſtly, $2r + \overline{p^2 - 3q} \times p = 42$, that is, $2r + 36 = 42$, or $r = 3$. Thence $r^2 - q^3 = -\frac{100}{27}$. But the Cubic-root of $r + \sqrt{r^2 - q^3}$, that is, of the ſurd Binomial $3 + \sqrt{-\frac{100}{27}}$, being extracted by the Methods which the Arithmetick of Surds will ſupply, will be found to be $-1 + \sqrt{-\frac{4}{3}}$, which is repreſented by $m + \sqrt{n}$. And therefore the Root $x = (p + 2m =)\ 4 - 2 = 2$. Alſo $x = (p - m \pm \sqrt{-3n} =)\ 4 + 1 \pm \sqrt{4} = 7$ or 3. Or again, another Cubic-root (for it has three) of the ſame Binomial $3 + \sqrt{-\frac{100}{27}}$ is $\frac{3}{2}$

$+\sqrt{-\frac{1}{12}}$, which is repreſented by $m+\sqrt{n}$. Therefore the Root $x=(p+2m=)\,4+3=7$. Alſo $x=(p-m\pm\sqrt{-3n}=)\,4-\frac{3}{2}\pm\sqrt{\frac{1}{4}}=3$ or 2. Laſtly, the third Cubic-root of the ſame Binomial $3+\sqrt{-\frac{100}{27}}$ is $-\frac{1}{2}-\sqrt{-\frac{25}{12}}(=m+\sqrt{n}.)$ And therefore the Root $x=(p+2m=)\,4-1=3$; and alſo $x=(p-m\pm\sqrt{-3n}=)\,4+\frac{1}{2}\pm\sqrt{\frac{25}{4}}=7$ or 2.

3. In the Equation $x^3=-15x^2-84x+100$, it will be $p=-5$, $q=-3$, $r=135$; and the Cubic-root of the Binomial $135+\sqrt{18252}$ is $3+\sqrt{12}$. Therefore the Root $x=-5+6=1$, and $x=-5-3\pm\sqrt{-36}=-8\pm\sqrt{-36}$, impoſſible.

4. In the Equation $x^3=34x^2-310x+1012$, it will be $p=\frac{34}{3}$, $q=\frac{226}{9}$, $r=\frac{5536}{27}$; and the Cubic-root of the Binomial $\frac{5536}{27}+\sqrt{\frac{707560}{27}}$ is $\frac{16}{3}+\sqrt{\frac{10}{3}}$. Therefore the Root $x=\frac{34}{3}+\frac{32}{3}=22$, and $x=\frac{34}{3}-\frac{16}{3}\pm\sqrt{-10}=6\pm\sqrt{-10}$, impoſſible.

5. In the Equation $x^3=28x^2+61x-4048$, it will be $p=\frac{28}{3}$, $q=\frac{967}{9}$, $r=-\frac{25010}{27}$; and the Cubic-root of the Binomial $-\frac{25010}{27}+\sqrt{-382347}$ is $\frac{41}{6}+\sqrt{-\frac{243}{4}}$. Therefore $x=\frac{28}{3}+\frac{41}{3}=23$, and $x=\frac{28}{3}-\frac{41}{6}\pm\frac{27}{2}=16$ or -11.

6. In the Equation $x^3=-x^2+166x-660$, it will be $p=-\frac{1}{3}$

$\frac{1}{3}$, $q = \frac{499}{9}$, $r = -\frac{9658}{27}$; and the Cubic-root of the Binomial $-\frac{9658}{27} + \sqrt{-\frac{1147205}{27}}$ is $-\frac{22}{3} + \sqrt{-\frac{5}{3}}$. Therefore $x = -\frac{1}{3} - \frac{44}{3} = -15$, and $x = -\frac{1}{3} + \frac{22}{3} \pm \sqrt{5} = 7 \pm \sqrt{5}$, irrational.

7. In the Equation $x^3 = 63x^2 + 99673x + 9951705$, it will be $p = 21$, $q = \frac{100996}{3}$, $r = 6031680$; and the Cubic-root of the Binomial $6031680 + \sqrt{-\frac{478871750431 36}{27}}$ is $183 + \sqrt{-\frac{529}{3}}$. Therefore $x = 21 + 366 = 387$, and $x = 21 - 183 \pm 23 = -139$ or -185.

And ſo we muſt proceed in other Examples. Now the Theorem may be inveſtigated in the following Manner. I ſuppoſe the Root of ſome Equation to be $z = a + b$, and multiplying cubically there will ariſe $z^3 = (a^3 + 3a^2b + 3ab^2 + b^3 =)\ a^3 + 3ab \times \overline{a+b} + b^3$. Now inſtead of $a + b$ ſubſtituting its Value z, it will become $z^3 = 3abz + a^3 + b^3$, which is a Cubic Equation conſtructed from the Root $z = a + b$, in which Equation the ſecond Term is wanting. Now that this may be reduced to a better Form, I aſſume the Equation $z^3 = 3qz + 2r$, which is now to repreſent the Equation $z^3 = 3abz + a^3 + b^3$. Therefore to tranſmute this into that, we ſhall have firſt $3q = 3ab$, and therefore $q^3 = a^3b^3$. Secondly, $2r = a^3 + b^3$, or $2ra^3 = (a^6 + a^3b^3 =)\ a^6 + q^3$. Then reſolving this Quadratick Equation, we ſhall have $a^3 = r + \sqrt{r^2 - q^3}$, and thence $b^3 = 2r - a^3 = r - \sqrt{r^2 - q^3}$. So that at laſt it will be $a = \sqrt[3]{r + \sqrt{r^2 - q^3}}$, and $b = \sqrt[3]{r - \sqrt{r^2 - q^3}}$. Therefore in the Cubic Equation $z^3 = 3qz + 2r$, we ſhall have the Root $z = (a + b =)$ $\sqrt[3]{r + \sqrt{r^2 - q^3}} + \sqrt[3]{r - \sqrt{r^2 - q^3}}$.

But this Root is really three-fold, according to the three-fold Value which $\sqrt[3]{r + \sqrt{r^2 - q^3}}$ and $\sqrt[3]{r - \sqrt{r^2 - q^3}}$ can acquire. For the Cubic-root of any Quantity whatever is three-fold, foraſmuch as the Cubic-root of Unity itſelf is either 1, or $-\frac{1}{2} + \frac{1}{2}\sqrt{-3}$, or $-\frac{1}{2} - \frac{1}{2}\sqrt{-3}$.

And this will appear by Cubing any one of theſe Quantities. Therefore if $r+\sqrt{r^2-q^3}$, or $1\times\overline{r+\sqrt{r^2-q^3}}$, be conſider'd as a Cube, its Cubic-root or Roots will be $\sqrt[3]{1}\times\sqrt[3]{r+\sqrt{r^2-q^3}}$; that is, firſt $1\times\sqrt[3]{r+\sqrt{r^2-q^3}}$, which we have above call'd $m+\sqrt{n}$, or $1\times\overline{m+\sqrt{n}}$. Secondly, $\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}$, which therefore will be $\frac{-1+\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}=\frac{-m-\sqrt{n}+m\sqrt{-3}+\sqrt{-3n}}{2}$. Thirdly, $\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}$, which therefore will be $\frac{-1-\sqrt{-3}}{2}\times\overline{m+\sqrt{n}}=\frac{-m-\sqrt{n}-m\sqrt{-3}-\sqrt{-3n}}{2}$. In like Manner the Apotome $r-\sqrt{r^2-q^3}$ or $1\times\overline{r-\sqrt{r^2-q^3}}$, being conſider'd as a Cube, will have the Cubic-root or Roots $\sqrt[3]{1}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$; that is, firſt, $1\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, which we have call'd $m-\sqrt{n}$, or $1\times\overline{m-\sqrt{n}}$. Secondly, $\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, which therefore will be $\frac{-1+\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}=\frac{-m+\sqrt{n}+m\sqrt{-3}-\sqrt{-3n}}{2}$. Thirdly, $\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$, which therefore will be $\frac{-1-\sqrt{-3}}{2}\times\overline{m-\sqrt{n}}=\frac{-m+\sqrt{n}-m\sqrt{-3}+\sqrt{-3n}}{2}$. And by a due Connexion of theſe Roots, we ſhall have $z=\sqrt[3]{r+\sqrt{r^2-q^3}}+\sqrt[3]{r-\sqrt{r^2-q^3}}=m+\sqrt{n}+m-\sqrt{n}=2m$. And ſecondly, $z=\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}+\frac{-1-\sqrt{-3}}{2}+\sqrt[3]{r-\sqrt{r^2-q^3}}=\frac{-m-\sqrt{n}+m\sqrt{-3}+\sqrt{-3n}}{2}+$

$\frac{-m+\sqrt{n}-m\sqrt{-3}+\sqrt{-3n}}{2}=-m+\sqrt{-3n}$: Laſtly, $z=$

$$\frac{-1-\sqrt{-3}}{2}\times\sqrt[3]{r+\sqrt{r^2-q^3}}+\frac{-1+\sqrt{-3}}{2}\times\sqrt[3]{r-\sqrt{r^2-q^3}}$$

$$=\frac{-m-\sqrt{n}-m\sqrt{-3}-\sqrt{-3n}}{2}+\frac{-m+\sqrt{n}+m\sqrt{-3}-\sqrt{-3n}}{2}$$

$=-m-\sqrt{-3}$. Theſe therefore will be the three Roots of the Cubic Equation $z^3=3qz+2r$. Now that the Parts are duly connected in the foregoing Manner, may be farther proved by being continually multiply'd together in the uſual Method. Finally, make $z=x-p$, and, by Subſtitution, the Equation will become $x^3-3px^2+3p^2x-p^3=3qx-3pq+2r$; which, by Tranſpoſition, will be the ſame Equation as above, and its Roots are the ſame as are there exhibited.

Here it deſerves to be obſerved, that all the Roots of any Cubic Equation are then real and poſſible, when the irrational Member of the Binomial $\sqrt{r^2-q^3}$ includes an Impoſſibility; that is, when q is an affirmative Quantity, and at the ſame Time its Cube is greater than the Square of r. But if this Member $\sqrt{r^2-q^3}$ is poſſible, that is, if q is a negative Quantity, or being affirmative if its Cube be leſs than the Square of r; then the Equation has but one real and poſſible Root, and the other two will be impoſſible.

In this Theorem if it ſhould be $p=0$, that is, if the ſecond Term of the Equation is wanting, we ſhall deſcend to the Caſe of thoſe Rules which are aſcribed to *Cardan*; the Solution of which is contain'd in what is here exhibited.

§. 2. In the Univerſal Biquadratic Equation

$$\begin{array}{rlllll} x^4 = & 4px^3 & +2qx^2 & +8rx & +4s, \\ & & -4p^2 & -4pq & -q^2 \end{array}$$

The four Roots are $x=p-a\pm\sqrt{p^2+q-a^2-\frac{2r}{a}}$,

$$x=p+a\pm\sqrt{p^2+q-a^2+\frac{2r}{a}};$$

Here a^2 is the Root of this Cubic Equation following,

$$\begin{array}{rlll} a^6 = & p^2a^4 & -2pra^2 & -r^2. \\ & +q & -s & \end{array}$$

Now when any Biquadratic Equation is given, a Compariſon muſt be made between its Terms, and the ſeveral Terms of this univerſal Equation, by which Means the Quantities p, q, r, s, will ſoon be found. And when theſe are known, the Value of a may be diſcover'd by the foregoing

Theorem. And then all the Roots of the given Equation will become known.

An Example or two may ſuffice to illuſtrate this Solution.

1. Suppoſe we were to extract the Roots of this Biquadratic Equation, $x^4 = 8x^3 + 83x^2 - 162x - 936$. Firſt, by what is preſcrib'd we ſhall have $4p = 8$, or $p = 2$. Secondly, $2q - 4p^2 = 83$, or $q = \frac{99}{2}$. Thirdly, $8r - 4pq = -162$, or $r = \frac{117}{4}$. Laſtly, $4s - q^2 = -936$, or $s = \frac{6057}{16}$. Hence $p^2 + q = \frac{107}{2}$, $2pr + s = \frac{7929}{16}r^2, = \frac{13689}{16}$. Wherefore $a^6 = \frac{107}{2}a^4 - \frac{7929}{16}a^2 - \frac{13689}{16}$. Now that this Equation, which is really Cubic, may be reſolved into its Roots, we muſt have Recourſe to the foregoing Theorem: In which $p = \frac{107}{6}$, $q = \frac{22009}{144}$, $r = \frac{2903923}{1728}$, and $r^2 - q^3 = -\frac{11940075}{16}$. But the Cubic-root of the Binomial $\frac{2903923}{1728} + \sqrt{-\frac{11940075}{16}}$ is $-\frac{53}{12} + \sqrt{-\frac{400}{3}}$; and therefore $a^2 = \frac{107}{6} - \frac{53}{6} = 9$, and alſo $a^2 = \frac{107}{6} + \frac{53}{12} \pm \sqrt{400} = \frac{169}{4}$ or $\frac{9}{4}$. Or which comes to the ſame, the ſix Roots of the foregoing Equation, which in reality is Cubo-cubick, are $a = \pm 3$, $a = \pm\frac{13}{2}$, $a = \pm\frac{3}{2}$, any one of which may be taken indifferently for the true Root of the Equation, and will be ſubſervient to our Purpoſe. Suppoſe in the preſent Caſe, that $a = 3$. Then by the Theorem it will be $x = p - a \pm \sqrt{p^2 + q - a^2 - \frac{2r}{a}} = 2 - 3 \pm \sqrt{4 + \frac{99}{2} - 9 - \frac{39}{2}} = -1 \pm 5 = 4$ or -6. Alſo $x = p + a \pm \sqrt{p^2 + q - a^2 + \frac{2r}{a}} = 2 + 3 \pm \sqrt{4 + \frac{99}{2} - 9 + \frac{39}{2}} = 5 \pm 8 = 13$ or -3; which are the four Roots of the given Equation.

2. In the Equation $x^4 = 20x^3 + 252x^2 - 6592x + 21312$, it will be $p = 5$, $q = 176$, $r = -384$, $s = 13072$. Hence $p^2 + q = 201$, $2pr + s = 9232$, and $r^2 = 147456$. And thence $a^6 = 201a^4 - 9232a^2 +$

$a^2 + 147456$. Now in the Theorem for Cubics, it will be $p = 67$, $q = \frac{4235}{3}$, and $r = 65219$. And the Cubic Root of the Binomial $65219 + \sqrt{\frac{3888930707 2}{27}}$ will be $\frac{77}{2} + \sqrt{\frac{847}{12}}$. Therefore $a^2 = 67 + 77 = 144$, or $a = 12$. Therefore $x = 5 - 12 \pm \sqrt{25+176-144+64} = -7 \pm 11 = 4$ or -18. Alſo $x = 5 + 12 \pm \sqrt{25+176-144-64} = 17 \pm \sqrt{-7}$, which two Roots are impoſſible.

Now the Inveſtigation of this Theorem is in this Manner. By the Multiplication of the two Quadratic Equations $z^2 + 2az - b = 0$, and $z^2 - 2az - c = 0$ into each other, I conſtruct the Biquadratic Equation $z^4 = \overline{4a^2 + b + c} \times z^2 + \overline{2ac - 2ab} \times z - bc$, in which the ſecond Term is wanting, and which I make equivalent to this Equation $z^4 = ez^2 + fz + g$. Whence firſt, $4a^2 + b + c = e$, or $b = e - 4a^2 - c$. Secondly, $2ac - 2ab = f$, or $2ac - 2ae + 8a^3 + 2ac = f$, whence $c = \frac{f}{4a} + \frac{1}{2}e - 2a^2$, and thence $b = e - 4a^2 - \frac{f}{4a} - \frac{1}{2}e + 2a^2 = -\frac{f}{4a} + \frac{1}{2}e - 2a^2$. Thirdly, $-bc = g$, or $-\frac{ff}{16a^2} + \frac{1}{4}e^2 - 2ea^2 + 4a^4 = -g$, that is, $a^6 = \frac{1}{2}ea^4 - \frac{1}{4}ga^2 - \frac{1}{16}ea^2 + \frac{1}{64}ff$, which is as it were a Cubic Equation, compoſed of the Root a^2, and the known or aſſumed Quantities e, f, g. Now that Root may be exhibited by the foregoing Theorem, and by the ſame Calculation the Quantities b and c will be known. But the Roots of the Equations $z^2 + 2az - b = 0$, and $z^2 - 2az - c = 0$, are $z = -a \pm \sqrt{a^2 + b}$ and $z = a \pm \sqrt{a^2 + c}$, or $z = -a \pm \sqrt{\frac{1}{2}e - a^2 - \frac{f}{4a}}$, and $z = a \pm \sqrt{\frac{1}{2}e - a^2 + \frac{f}{4a}}$, which therefore will be the Roots of the Equation $z^4 = ez^2 + fz + g$, when a or a^2 is known from the Equation $a^6 = \frac{1}{2}ea^4 - \frac{1}{4}ga^2 - \frac{1}{16}ea^2 + \frac{ff}{64}$. Now that this Equation may become univerſal, and furniſhed with all its Terms, make $z = x - p$, then $x^4 - 4px^3 + 6p^2x^2 - 4p^3x + p^4 = ex^2 - 2pex + p^2e + fx - fp + g$, alſo $x = p - a$

$\pm\sqrt{\frac{1}{2}e-a^2-\frac{f}{4a}}$, and $x=p+a\pm\sqrt{\frac{1}{2}e-a^2+\frac{f}{4a}}$. Laſtly, for Concinnity and Brevity Sake, make $e=2q+2p^2$, and $f=8r$; then $x^4-4px^3+4p^2x^2=2qx^2-4pqx+2p^2q+p^4+8rx-8pr+g$, $x=p-a\pm\sqrt{p^2+q-a^2-\frac{2r}{a}}$, alſo $x=p+a\pm\sqrt{p^2+q-a^2+\frac{2r}{a}}$, and $a^2=\overline{p^2+q}\times a_4\overline{-\frac{1}{4}g+\frac{1}{4}p^4+\frac{1}{2}p^2q+\frac{1}{4}q^2}a^2.+r^2$. Finally, make $g=4s-q^2+8pr-p^4-2p^2q$, and the foregoing Equations become

$$\begin{array}{llll} x_4=4px^3 & +2qx^2 & +8rx & +4s, \\ & -4p^2 & -4pq & -q^2 \end{array} \quad \text{and} \quad \begin{array}{lll} a^6=p^2a^4 & -2pra^2 & +r^2; \\ +q & & -s \end{array}$$

that is, all Things become as ſuppoſed above.

§. 3. Hitherto concerning the Analytical Solution of Cubic and Biquadratic Equations. Now becauſe their Geometrical Effection by the Parabola is commonly taught, and is much valued by ſome, I ſhall exhibit it here more univerſally, and yet more compendiouſly.

Any Cubic or Biquadratic Equation being given, a Compariſon muſt be made between its Terms, and the reſpective Terms of this Equation following.

$$\begin{array}{lllll} x^4= & \frac{2p}{q}x^3 & +\frac{4pr}{q}x^2 & +\frac{2p^2}{q}x & +p^2, \\ & -4r & -4r^2 & -\frac{2ps}{q} & -q^2 \\ & & +2s & +4rs & -s^2 \\ & & -1 & -2q & +t^2 \end{array}$$

by which Means the Values of p, q, r, s, t, will eaſily be found, any one of them being aſſumed at Pleaſure. Then in any given Parabola AVB, whoſe principal Vertex is V, its Axis VS, and VT perpendicular to the Fig. 31. Axis; let there be taken $VS=p$, within the Parabola, and in the Angle SVT let there be inſcribed $ST=q$, which being produced let it cut the Parabola in two Points N and O. Let ON be biſected in M, and thro' M let MA be drawn, parallel to the Axis and meeting the Parabola in A. Draw AL parallel to ON, and let AL be the *Latus rectum* of the Parabola to the Diameter AM, and let the ſame be Unity. In AL, produced both Ways if neceſſary, take $AG=r$, and from G draw GR parallel to the Axis, ſo that it may cut the Parabola in B, from whence take $BR=s$. From the Point laſt found R draw RE parallel and equal to VT, and let it lie to the left Hand in reſpect of R, if q is an affirmative Quantity, otherwiſe to the right Hand if q be negative. And the ſame Thing is to be underſtood of AG and BR, which muſt be drawn on the contrary Side, if the Values of r and s happen to be negative.

Laſtly, with Center E and Radius $EC = t$, let a Circle $CKkc$ be deſcribed, which will cut the Parabola in ſo many Points, as there are real Roots in the given Equation. For from thoſe Points C, K, let there be drawn CP, $k\Pi$, &c. parallel to ST, and terminated at the right Line GR produced if need be. Every one of theſe will be x, or the required Root of the given Equation. Thoſe lying to the right Hand will be affirmative Roots, and thoſe on the left Hand will be negative. A Point of Contact, if any ſuch ſhould be, is here taken for two Points of Interſection, that are infinitely near to each other.

This will be the only Difference between Cubic and Biquadratic Equations, conſtructed after this Manner, that in the former, becauſe of the laſt Term being abſent in the foregoing Equation, it will always be $pp - qq - ss + tt = 0$, or $t = \sqrt{ss + qq - pp}$. Therefore Center E and Radius $EC = \sqrt{BRq + (ERq)\, STq - USq}$ any Circle $CKkc$ being deſcribed, one of the Roots CP in the foregoing Conſtruction becomes nothing.

Now theſe Poſitions are demonſtrated in the following Manner. Suppoſing all Things as before conſtructed, and producing CP if needful till it meets AM in H, CH will be the Ordinate of the Parabola to the Diameter AH, and therefore $CHq = AL \times AH = AH$, becauſe of $AL = 1$. But $CH = CP + AG$, and $AH = GB + BP$, and therefore $CPq + 2AG \times CP + AGq = GB + BP$. But becauſe of the Nature of the Parabola it will be $AGq = BG$, whence $CPq + 2AG \times CP = BP$. Now from the Point C let there be drawn CD perpendicular to BP, which may alſo meet EI parallel to BP in the Point I. Now becauſe of ſimilar Triangles CDP and TVS, it will be $DP = \frac{VS \times CP}{ST}$, and $CD = \frac{VT \times CP}{ST}$; and therefore $CPq + 2AG \times CP = BP = DP + DB = \frac{VS \times CP}{ST} + BR - IE$. Or $CPq + 2AG \times CP - \frac{VS}{ST}CP - BR = -IE$. But $IEq = CEq - CIq$ $= CEq - CDq - VTq - 2CD \times VT = CEq - \frac{VTq \times CPq}{STq}$ $- VTq - \frac{2VTq \times CP}{ST} =$ (becauſe of $VTq = STq - SVq$) CEq $- CPq + \frac{SVq}{STq}CPq - STq + SVq - 2ST \times CP + \frac{2SVq}{ST}CP$, this therefore will be equal to the Square whoſe Side is $CPq + 2AG \times CP - \frac{VS}{ST}CP - BR$. And when this Equation is reduced to the Terms p, q, r, s, t, it will become the very Equation propoſed.

Hence it appears, that any the ſame Biquadratic Equation will admit of innumerable different Conſtructions by the Parabola, according to the different Values of that Quantity which we ſaid might be aſſumed at Pleaſure. But the moſt ſimple Caſe is, by making $VS = p = 0$, and the Conſtruction paſſes into the common one (as to the Thing itſelf) in which the right Lines CP, *&c.* which are the Repreſentatives of the Roots, are perpendicular to the Axis. Then the Equation becomes

$$\begin{array}{llllll} x^4 = -4rx^3 & -4r^2 & x^2 & +4rs & x & -q^2 \\ & +2s & & -2q & & -s^2 \\ & -1 & & & & +t^2 \end{array}$$

which is eaſily conſtructed as above.

§. 4. But leaſt the Organical Deſcription of the Parabola ſhould ſeem too difficult, we may have Recourſe to a certain Mechanical Artifice, to be perform'd by Means of a Plummet, or Thread with a Weight hanging at the End of it; by Help of which the laſt Equation may be conſtructed very eaſily and exactly, and therefore the Roots of any Cubic or Biquadratic Equations may be found. This Conſtruction, which we Fig. 32. may call a Mechanical one, is after this Manner.

Againſt a ſmooth and upright Wall, or any other Plain perpendicular to the Horizon, at any Point F let there be hung a very fine flexible Thread FP, with any Weight P hung at its Extremity. In this Thread let any Point N be mark'd, which is at a ſufficient Diſtance from the Point of Suſpenſion F; or it may be tyed with a ſmall Knot N. Then taking at Pleaſure NO for Unity, at the middle Point M (and in the aforeſaid Plain,) let the right Line AQ be drawn parallel to the Horizon, and produced both Ways as far as is neceſſary. Theſe Things being prepared in general, for Application to any particular Caſe, make $AQ = r$; the Quantities q, r, s, t, being firſt determined in the laſt Equation, either Arithmetically or Geometrically, according to the Exigence of the given Equation. Then with a ſmall Style or Bodkin, or with the ſlender Point of a Pair of Compaſſes, let the Thread be inflected and moved from its Place, till the Point of Inflection falls upon a certain Point B, and the Knot N falls at the ſame Time on the Point laſt found Q. In BQ from that Point B take $BR = S$, and at R raiſe the Perpendicular $RE = q$ to the Line BR. But thoſe Lines AQ, BR, RE, muſt fall the contrary Way from their initial Points, if it ſhould happen that the Values of r, s, q, ſhould come out negative. *Laſtly*, let one Leg of the Compaſſes be fixed in the Point found E, and let the other Leg, extended to the Diſtance $EZ = t$, be carried about with a circular Motion, taking with it the Thread FZP. By this Circulation of the Thread the Weight P will ſometimes aſcend, and ſometimes deſcend with a reciprocal Motion, and the Knot N will ſometimes be above and ſometimes below the Horizontal Line AQ. But whenever the Knot N ſhall be found in the Line AQ, ſuppoſe in the Points $D\, d\, \Delta\, \delta$, ſucceſſively; it will cut off the right Lines DQ, dQ, ΔQ, δQ, which will be all the real Roots of the given Equation: That is, thoſe on the right Hand will be the affirmative Roots, and thoſe on the Left the negative. The Demonſtration will be manifeſt from what goes before, and attending to the Parabola that will paſs through the Points $BCckK$. For making F the Focus of the Parabola, whoſe Diſtance from the Vertex is $\frac{1}{4}ON$, it is known that all the Lines as $FB+BQ$, $FC+CD$, *&c.* always make the ſame Sum.

And from the Principles here laid down it will not be difficult to conſtruct an Inſtrument, which will be neat enough, and as accurate as you pleaſe, by the Help of which, and with very little Trouble, the Roots of all theſe Equations may be found, and exhibited to Ocular Inſpection.

XVI. Let n be any Number whatever, y an unknown Quantity, and let a be any Quantity intirely known, or what they call the *Homogeneum Comparationis*; and let the Relation of theſe be expreſſed by the Equation.

$$ny+\frac{nn-1}{2\times 3}ny^3+\frac{nn-1}{2\times 3}\times\frac{nn-9}{4\times 5}ny^5+\frac{nn-1}{2\times 3}\times\frac{nn-9}{4\times 5}\times\frac{nn-25}{6\times 7}ny^7, \&c. = a.$$

Equations of the 3d, 5th, 7th, 9th, *&c. Powers ſolv'd Analytically by Mr.* Abr. de Moivre, n. 309. p. 2368.

It is plain from the Nature of this Series, that if n is taken any odd Number, (that is, an Integer, but it is all one whether affirmative or negative) then the Series will ſtop of its own Accord, and the Equation becomes one of thoſe deſcribed in the Title; the Root of which is

$$(1)\ y=\tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}+a}-\frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}+a}}$$

$$\text{or }(2)\ y=\tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}+a}-\tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}-a}$$

$$\text{or }(3)\ y=\frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}}-\tfrac{1}{2}\sqrt[n]{\sqrt{1+aa}-a}$$

$$\text{or }(4)\ y=\frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}}-\frac{\frac{1}{2}}{\sqrt[n]{\sqrt{1+aa}-a}}$$

For Examble, let it be this Equation of the fifth Power, $5y+20y^3+16y^5=4$, whoſe Root is to be found. In this Caſe 'tis $n=5$, and $a=4$. Then the Root, according to the firſt Form, will be

$y=$

$y = \frac{1}{2}\sqrt[5]{\sqrt{17}+4} - \frac{\frac{1}{2}}{\sqrt[5]{\sqrt{17}+4}}$, which is reduced very expediouſly to common Numbers in this Manner. 'Tis $\sqrt{17}+4 = 8,1231$, whoſe Logarithm is 0, 9097164, the fifth Part of which is 0, 1819433, and the Number anſwering to this is $1,5203 = \sqrt[5]{\sqrt{17}+4}$. Now the Arithmetical Complement of 0, 1819433 is 9, 8180567, to which anſwers the Number $0,6577 = \frac{1}{\sqrt[5]{\sqrt{17}+4}}$. Therefore the half-Difference of theſe Numbers is $0,4313 = y$.

It may obſerved, that inſtead of the general Root it may be ſufficient to take $y = \frac{1}{2}\sqrt[n]{2a} - \frac{\frac{1}{2}}{\sqrt[n]{2a}}$, whenever the Number n is very large in reſpect of Unity. As if the Equation were $5y + 20y^3 + 16y^5 = 682$; the Log. of $2a = 3,1348143$, a fifth Part of which is 0, 6269628, and the Number anſwering to this is 4, 236. The Arithmetical Complement is 9, 3730372, whoſe Number is 0, 236, and the Half-difference of theſe Numbers is $2 = y$.

Again, if in the foregoing Equation the Signs are made alternately affirmative and negative, or which is the ſame Thing, if we had ſuch a Series as this following,

$$ny + \frac{1-nn}{2\times3}ny^3 + \frac{1-nn}{2\times3}\times\frac{9-nn}{4\times5}ny^5 + \frac{1-nn}{2\times3}\times\frac{9-nn}{4\times5}\times\frac{25-nn}{6\times7}ny^7, \&c. = a,$$

the Root will be

$$(1)\ y = \frac{1}{2}\sqrt[n]{a+\sqrt{aa-1}} + \frac{\frac{1}{2}}{\sqrt[n]{a-\sqrt{aa-1}}}$$

$$\text{or } (2)\ y = \frac{1}{2}\sqrt[n]{a+\sqrt{aa-1}} + \frac{1}{2}\sqrt[n]{a-\sqrt{aa-1}}$$

$$\text{or } (3)\ y = \frac{\frac{1}{2}}{\sqrt[n]{a-\sqrt{aa-1}}} + \frac{1}{2}\sqrt[n]{a-\sqrt{aa-1}}$$

or (4) $$y = \frac{\frac{1}{2}}{\sqrt[n]{a - \sqrt{aa-1}}} + \frac{\frac{1}{2}}{\sqrt[n]{a + \sqrt{aa-1}}}$$

Here it is to be obſerved, that if $\frac{n-1}{2}$ ſhould be an odd Number, the Sign of the Root when found muſt be changed into its contrary.

Let this Equation be propoſed $5y - 20y^3 + 16y^5 = 6$; whence $n = 5$ and $a = 6$. Then the Root $y = \frac{1}{2}\sqrt[5]{6 + \sqrt{35}} + \frac{\frac{1}{2}}{\sqrt[5]{6 + \sqrt{35}}}$.

Or becauſe $6 + \sqrt{35} = 11,916$, the Logarithm of this will be 1, 0761304, and its fifth Part 0, 2152561, and its Arithmetical Complement 9, 7847439. The Numbers belonging to theſe Logarithms reſpectively are 1, 6415 and 0, 6091, whoſe Semiſum 1, 1253 $= y$.

But if it ſhall happen that a is leſs than Unity, then the ſecond Form of the Root is rather to be made Choice of, as fitter for the Purpoſe. Thus if the Equation were $5y - 20y^3 + 16y^5 = \frac{61}{64}$, then $y = \frac{1}{2}\sqrt[5]{\frac{61}{64} + \sqrt{\frac{-375}{4096}}} + \frac{1}{2}\sqrt[5]{\frac{61}{64} - \sqrt{\frac{-375}{4096}}}$. And if by any Means the Root of the fifth Power of Binomials can be extracted, the Root would come out true and poſſible, notwithſtanding that the Expreſſion ſeems to include an Impoſſibility. Now the fifth Root of the Binomial $\frac{61}{64} + \sqrt{\frac{-375}{4096}}$ is $\frac{1}{4} + \frac{1}{4}\sqrt{-15}$; and of the Binomial $\frac{61}{64} - \sqrt{\frac{-375}{4096}}$ the fifth Root is alſo $\frac{1}{4} - \frac{1}{4}\sqrt{-15}$: And half the Sum of theſe Binomials is $\frac{1}{4} = y$. Now if this Extraction cannot be perform'd, or ſhould ſeem any Thing difficult; the Reſult may always be found by the Table of Natural Sines in the following Manner.

To Radius 1 let $a = \frac{61}{64} = 0,\ 96112$ be the Sine of a certain Arch, which therefore will be 72°. 23′, a fifth Part of which, (becauſe $n = 5$) is 14°. 28′. The Sine of this is 0, 24981, which is nearly $\frac{1}{4}$. Nor is it otherwiſe in Equations of higher Degrees.

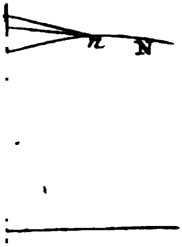
The Method of Approximating, *in Extracting the* Roots *of* Equations *in Numbers*, improv'd by *Dr.* B. Taylor, n. 352. *p.* 610.
* Vid. *ſup.* V. I. C. I. S. XX.

XVII. Dr. *Halley* has publiſh'd * a very compendious and uſeful Method of extracting the Roots of adfected Equations of the common Form in Numbers. This Method proceeds by aſſuming the Root deſired nearly true to one or two Places in Decimals (which is done by a Geometrical Conſtruction, or by ſome other convenient Way) and correcting the Aſſumption by comparing the Difference between the true Root and the aſſumed, by Means of a new Equation whoſe Root is that Difference, and which he ſhews how to form from the Equation propoſed, by Subſtitution of the Value of the Root ſought, partly in known, and partly in unknown Terms.

In doing this he makes Uſe of a Table of Products (which he calls *Speculum Analyticum*) by which he computes the Coefficients in the new Equation for finding the Difference mentioned. This Table, I obſerved, was formed in the ſame Manner from the Equation propoſed, as the Fluxions are, taking the Root ſought for the only flowing Quantity, its Fluxion for Unity, and after every Operation dividing the Product ſucceſſively by the Numbers 1, 2, 3, 4, *&c.* Hence I ſoon found that this Method might eaſily and naturally be drawn from *Cor.* 2. *Prop.* 7. of my *Methodus Incrementorum*, and that it was capable of a further Degree of Generality, it being applicable, not only to Equations of the common Form, (*viz.* ſuch as conſiſt of Terms wherein the Powers of the Root ſought are poſitive and integral, without any radical Sign) but alſo to all Expreſſions in general, wherein any Thing is propoſed as given which by any known Method might be computed; if *vice verſâ*, the Root were conſidered as given: Such as are all radical Expreſſions of Binomials, Trinomials, or of any other Nomial, which may be computed by the Root given, at leaſt by Logarithms, whatever be the Index of the Power of that Nomial; as likewiſe Expreſſions of Logarithms, of Arches by the Sines or Tangents, of Areas of Curves by the *Abſciſſas*, or any other Fluents or Roots of fluxional Equations, *&c.*

For the Sake of this great Generality, it may not be improper to ſhew how this Method is derived from the foreſaid *Corollary*; therefore z and x being two flowing Quantities (whoſe Relation to one another may be expreſſed by any Equation whatſoever) by this *Corollary*, while

x



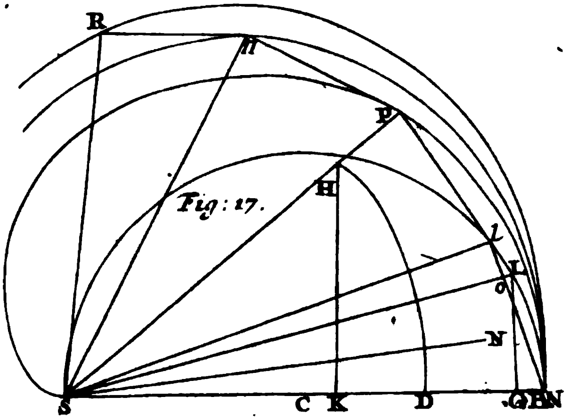


Fig: 17.

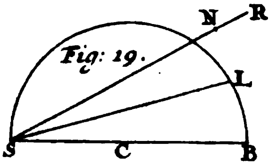


Fig: 19.

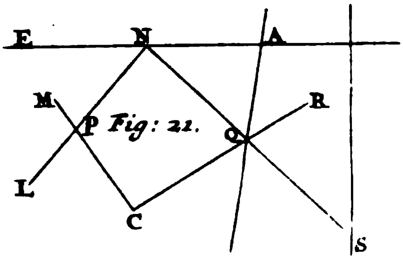


Fig: 21.

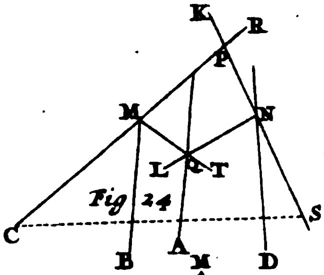


Fig 24

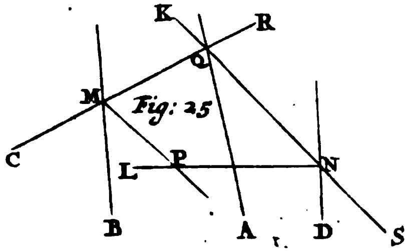


Fig: 25

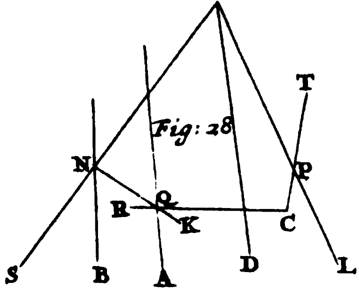


Fig: 28

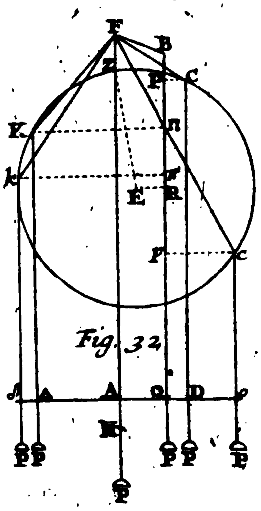
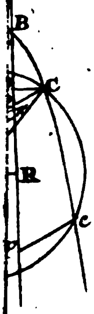


Fig. 32.



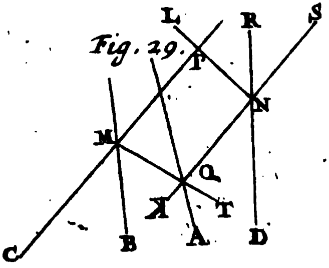


Fig. 29.

z by flowing uniformly becomes $z+v$, x will become $x+\frac{\dot{x}}{1\,.\,\dot{z}}v$

$+\frac{\ddot{x}}{1\,.\,2\dot{z}^2}v^2+\frac{\dddot{x}}{1\,.\,2\,.\,3\dot{z}^3}v^3+$ &c. or $x\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\times2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c.

for $\dot{z}$ putting 1.

Hence if y be the Root of any Expreſſion formed of y and known Quantities, and ſuppoſed equal to nothing, and z be a Part of y, and x be formed of z and the known Quantities, in the ſame Manner as the Expreſſion made equal to nothing is formed of y; and let y be equal to $z+v$; the Difference v will be found by extracting the Root of this Expreſſion $x+\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\,.\,2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c. $=0$. For in this Caſe z being become $z+v=y$, x, which is now become $x+\dot{x}v+\frac{\ddot{x}v^2}{2}$ + &c. muſt become equal to nothing.

The Root v in the Equation $x+\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\,.\,2}+\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+$ &c. $=0$, is to be found upon the Suppoſition of its being very ſmall with reſpect to z, (as it muſt be, if z be taken tolerably exact) by which Means the Terms $\frac{\dddot{x}v^3}{1\,.\,2\,.\,3}+\frac{\ddddot{x}v^4}{1\,.\,2\,.\,3\,.\,4}+$ &c. may be neglected, upon account of their Smallneſs with reſpect to the other Terms, ſo as to leave the Equation $x+\frac{\dot{x}v}{1}+\frac{\ddot{x}v^2}{1\,.\,2}=0$, for finding the firſt Approximation of v.

By extracting the Root of this Equation, we have

$v=\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}-\frac{2x}{\ddot{x}}}-\frac{\dot{x}}{\ddot{x}}$. That is, First, $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}-\frac{2x}{\ddot{x}}}-\frac{\dot{x}}{\ddot{x}}$, if $x+\dot{x}v+\frac{\ddot{x}v^2}{2}=0$.

Second, $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}+\frac{2x}{\ddot{x}}}-\frac{\dot{x}}{\ddot{x}}$, if $-x+\dot{x}v+\frac{\ddot{x}v^2}{2}=0$.

Third, $\frac{\dot{x}}{\ddot{x}}-\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}-\frac{2x}{\ddot{x}}}$, if $x-\dot{x}v+\frac{\ddot{x}v^2}{2}$, &c. $=0$.

Fourth, $\frac{\dot{x}}{\ddot{x}}-\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}-\frac{2x}{\ddot{x}}}$, if $-x-\dot{x}v+\frac{\ddot{x}v^2}{2}$, &c. $=0$.

This Approximation gives v exact to twice as many Places as there are true Figures in z, and therefore trebles the Number of true Figures in the Expreſſion of y by $z+v$, which may be taken for a new Value of z, for computing a ſecond v, ſeeking other Values of x, $\dot{x}$, $\ddot{x}$, &c. Though when z is tolerably exact (which it may be eſteemed when it contains two or three or more Figures true in the Value of y, according to the Number of Figures the Root is propoſed to be computed to) the Calculation may be reſtor'd without ſo much Trouble, only by taking $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}\pm\frac{2x}{\ddot{x}}-\frac{2\dddot{x}}{2\cdot3\ddot{x}}}\,v^3-\frac{2\ddddot{x}}{1\cdot2\cdot3\cdot4\ddot{x}}v^4$, &c. inſtead of $\sqrt{\frac{\dot{x}^2}{\ddot{x}^2}\pm\frac{2x}{\ddot{x}}}$ taking every Time for v its Value laſt computed.

From the ſame Equation $x+\dot{x}v+\frac{\ddot{x}v^2}{2}+\frac{\dddot{x}v^3}{1\cdot2\cdot3}+$ &c. $=0$, may be gather'd alſo a rational Form, *viz.* $v=\frac{-x}{\dot{x}-\frac{x\ddot{x}}{2\dot{x}}}$. For neglecting the Terms $\frac{\dddot{x}v^3}{1\cdot2\cdot3}$, &c. we have $v=\frac{-x}{\dot{x}+\frac{\ddot{x}}{2}v}$ which is nearly

=

$= \frac{-x}{\dot{x}}$. Therefore in the Diviſor inſtead of v writing $\frac{-x}{\dot{x}}$ we have more exactly $v = \frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$ that is,

1. $\frac{-x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$, when $x + \dot{x}v + \frac{\ddot{x}v^2}{2}$ *&c.* $= 0$.

2. $\frac{x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}$, when $-x + \dot{x}v + \frac{\ddot{x}v^2}{2}$ *&c.* $= 0$.

3. $\frac{x}{\dot{x} - \frac{\ddot{x}x}{2\dot{x}}}$, when $x - \dot{x}v + \frac{\ddot{x}v^2}{2}$ *&c.* $= 0$.

4. $\frac{-x}{\dot{x} + \frac{\ddot{x}x}{2\dot{x}}}$, when $-x - \dot{x}v + \frac{\ddot{x}v^2}{2}$ *&c.* $= 0$.

This *Formula* will alſo triplicate the Number of true Figures in x. And the Calculation may be repeated, after every Operation, taking for a Diviſor $\dot{x} \pm \frac{\ddot{x}}{2}v + \frac{\dddot{x}v^2}{1 \cdot 2 \cdot 3} + \frac{\ddddot{x}v^3}{1 \cdot 2 \cdot 3 \cdot 4} +$ *&c.* inſtead of $\dot{x} + \frac{\ddot{x}x}{2\dot{x}}$.

Dr *Halley* has fully explained the Manner of uſing both theſe *Formula's* in Equations of the common Form; wherefore I ſhall be the ſhorter in explaining two or three Examples of another Sort.

Ex. 1. Let it be propoſed to find the Root of this Equation $\overline{y^2+1}\big|^{\sqrt{2}} + y - 16 = 0$. In this Caſe, for y writing z, and for 0 writing x, we have $\overline{z^2+1}\big|^{\sqrt{2}} + z - 16 = x$. Whence by taking the Fluxions, we have $\dot{x} = 2\sqrt{2} \times z \times \overline{z^2+1}\big|^{\sqrt{2}-1} + 1$, and $\ddot{x} = 2\sqrt{2} \times \overline{8-4\sqrt{2}\,z^2} \times \overline{z^2+1}\big|^{\sqrt{2}-2}$. For finding the firſt Figures of the Root y, for $\sqrt{2}$ take $\frac{3}{2}$, and we have the Equation $\overline{y^2+1}\big|^{\frac{3}{2}} + y - 16 = 0$, which being expanded gives $y^6 + 3y^4 + 2y^2 + 32y - 255 = 0$.

By this Equation I find that for the firſt Suppoſition we may take $z = 2$. Therefore in order to find v, let us now make $\sqrt{2} = \frac{7}{5}$, (which is nearer than before) and we have $x = \overline{z^2+1}\big|^{\frac{7}{5}} + z - 16 = \overline{z^2+1}\big|^{\frac{7}{5}} - 14 = 5^{\frac{7}{5}} - 14 = -4{,}48$; $\dot{x} = 10{,}66$; $\ddot{x} = 4{,}72$. Whence by the ſecond rational Form

$$v = \frac{4{,}48}{10{,}66 + \dfrac{4{,}72 \times 4{,}48}{2 \times 10{,}66}} = 0{,}38$$

which muſt be too big, becauſe $\frac{7}{5} < \sqrt{2}$, and therefore will require a larger Value of y to exhauſt the Equation, than where $\sqrt{2}$ is exact. For the ſecond Suppoſition therefore, let us take $z = 2{,}3$, and make $\sqrt{2} = 1{,}4142136$, and by help of the Logarithms we ſhall have $\overline{z^2+1}\big|^{\sqrt{2}} = 13{,}47294$, whence $x = -0{,}22706$; $\dot{x} = 14{,}93429$, and $\ddot{x} = 5{,}18419$. Hence by the 2d irrational *Formula*

$$v = \sqrt{\frac{14{,}93429^2}{5{,}18419^2} + \frac{0{,}45412}{5{,}18419}} - \frac{14{,}93429}{5{,}18419} = 0{,}0516, \text{ which gives}$$

$y = z + v = 2{,}31516$, which is true to ſix Places. If you deſire it more exact than to the Extent of the Tables of Logarithms, taking $z = 2{,}31516$ for the next Suppoſition, the Calculation muſt be repeated by computing $\overline{z\,z+1}\big|^{\sqrt{2}}$ to a ſufficient Number of Places; which muſt be done by the Binomial Series, or by making a Logarithm on Purpoſe, true to as many Places as are neceſſary.

Ex. 2. For another Example, let it be required to find the Number whoſe Logarithm is 0, 29, ſuppoſing we had no other Table of Logarithms, but Mr. *Sharp*'s of 200 Logarithms to a great many Places. This amounts to the reſolving this Equation $ly = 0,\ 29$, or $ly - 0,\ 29 = 0$. Hence therefore we have $x = lx - 0,\ 29$, $\dot{x} = \frac{a}{z}$ (*a* being the *Modulus* belonging to the Table we uſe, *viz.* 0, 4342944819, &c.) $\ddot{x} = \frac{-a}{z^2}$, $\dddot{x} = \frac{2a}{z^3}$, $\ddddot{x} = \frac{-6a}{z^4}$, &c.

In this Caſe becauſe $\ddot{x}$ has a negative Sign, changing the Signs of all the Coefficients, the Canon for v will be found in the fourth Caſe, which in the irrational Form gives $v = \frac{\dot{x}}{\ddot{x}} \sqrt{\frac{\dot{x}^2}{\ddot{x}^2} + \frac{2x}{\ddot{x}} - \frac{2\dddot{x}}{2 \cdot 3\ddot{x}} v^3 - \frac{2\ddddot{x}}{2 \cdot 3 \cdot 4\ddot{x}} v^4 \&c.} = z - \sqrt{z^2 + \frac{\overline{2lz - 0,\ 58}}{a} \times z^2 + \frac{2v^3}{3z} - \frac{2v^4}{4z^2} + \frac{2v^5}{5z^3}}$, &c. In this Caſe to avoid often dividing by z, it will be moſt convenient to compute $\frac{v}{z}$, which is got from this Equation $\frac{v}{z} = 1 - \sqrt{1 + \frac{2lz - 0,\ 58}{a} + \frac{2v^3}{3z^3} - \frac{2v^4}{4z^4} + \frac{2v^5}{5z^5}}$, &c. The neareſt Logarithm, in the Tables propoſed, to the propoſed Logarithm 0, 29 is 0, 2900346114, its Number being 1, 95. Therefore for the firſt Suppoſition taking $z = 1,\ 95$, we have x ($= lz - 0,\ 29 = 0,\ 2900346114 - 0,\ 29) = 0,\ 0000346114$, and $\frac{2lz - 0,\ 58}{a} = \frac{0,\ 0000692228}{0,\ 4342944819} = 0,\ 00015939139$, and $1 + \frac{2lz - 0,\ 58}{a} = 1,\ 00015939139$. Whence for the firſt Approximation we have $\frac{v}{z} = 1 - \sqrt{1,00015939139} =$ $- 0,00007969247$, and $v = - 0,00015540032$, and $y = z + v =$ $1,94984459968$. Which is true to eleven Places, and may eaſily be corrected by the Terms $\frac{2v^3}{3z}$, &c. which I leave to the Reader's Curioſity.

Being upon the Subject of Approximations, it may not be amiſs to ſet down here two Approximations I have formerly hit upon. The one is a Series of Terms for expreſſing the Root of any Quadratic Equation; and the other is a particular Method of approximating in the Invention of Logarithms, which has no Occaſion for any of the Tranſcendental Methods, and is expeditious enough for making the Tables without much Trouble.

A general Series for expreſſing the Root of any Quadratic Equation.

2. Any Quadratic Equation being reduc'd to this Form $xx - mqx + my = 0$, the Root x will be expreſs'd by this Series of Terms.

$$x = \frac{y}{q} + A \times \frac{1}{\frac{mq^2}{y} - 2} + B \times \frac{1}{a^2 - 2} + C \times \frac{1}{b^2 - 2}$$

$$+ D \times \frac{1}{c^2 - 2}$$ &c. which muſt be thus interpreted.

1. The Capital Letters A, B, C, &c. ſtand for the whole Terms with their Signs, preceding thoſe whereen they are found, as

$$B = A \times \frac{1}{\frac{mq^2}{y} - 2}.$$

2. The little Letters a, b, c, &c. in the Diviſors, are equal to the whole Diviſors of the Fraction in the Terms immediately preceding; thus $b = a^2 - 2$.

For an Example of this, let it be required to find $\sqrt{2}$. Putting $\sqrt{2} = x + 1$, we have $x^2 + 2x - 1 = 0$, which being compared with the general *Formula*, gives $mq = -2$, and $my = -1$; therefore for m taking -1, we have $q = 2$, and $y = 1$, which Values ſubſtituted in the Series give $x = \frac{1}{2} - \frac{1}{2\times6} - \frac{1}{2\times6\times34} - \frac{1}{2\times6\times34\times1154} - \frac{1}{2\times6\times34\times1154\times1331714}$, &c. The Fractions here wrote down giving the Root true to twenty three Places.

A New Method of computing Logarithms.

3. This Method is founded upon theſe Conſiderations.

1. That the Sum of the Logarithms of any two Numbers is the Logarithm of the Product of thoſe two Numbers multiplied together.

2. That the Logarithm of Unit is nothing; and conſequenly that the nearer any Number is to Unit, the nearer will its Logarithm be to 0. *3dly*, That the Product by Multiplication of two Numbers, whereof one is bigger, and the other leſs than Unit, is nearer to Unit than that of the two Numbers which is on the ſame Side of Unit with itſelf; for Example, the two Numbers being $\frac{2}{3}$ and $\frac{4}{3}$, the Product $\frac{8}{9}$ is leſs than Unit, but nearer to it than $\frac{2}{3}$, which is alſo leſs than Unit. Upon theſe Conſiderations, I found the preſent Approximation; which will be the beſt explain'd by an Example. Let it therefore be propoſed to find the Relation of the Logarithms of 2 and of 10.

In order to this, I take two Fractions $\frac{128}{100}$ and $\frac{8}{10}$, *viz.* $\frac{\overline{2}|^{7}}{\overline{10}|^{2}}$ and $\frac{\overline{2}|^{3}}{\overline{10}|^{1}}$ whoſe Numerators are Powers of 2, and their Denominators Powers of 10; one of them being bigger, and the other leſs than 1. Having ſet theſe down in Decimal Fractions in the firſt Column of the Table annexed, againſt them in the ſecond Column I ſet A and B for their Logarithms, expreſſing by an Equation the Manner how they are compounded of the Logarithms of 2 and 10, for which I write *l* 2 and *l* 10. Then multiplying the two Numbers in the firſt Column together, I have a third Number 1,024, againſt which I write C for its Logarithm, expreſſing likewiſe by an Equation in what Manner C is formed of the foregoing Logarithms A and B. And in the ſame Manner the Calculation is continued; only obſerving this *Compendium*, that before I multiply the two laſt Numbers already got in the Table, I conſider what Power of one of them muſt be uſed to bring the Product the neareſt to Unit that can be. This is found, after we have gone a little Way in the Table, only by dividing the Differences of the Numbers from Unit one by the other, and taking the Quotient with the neareſt, for the Index of the Power wanted. Thus the two laſt Numbers in the Table being 0, 8 and 1, 024, their Differences from Unit are 0, 200 and 0, 024; therefore $\frac{0,200}{0,024}$ gives 9 for the Index; wherefore multiplying the ninth Power of 1, 024 by 0, 8, I have the next Number 0, 990352031429, whoſe Logarithm is $D = 9C + B$. In ſeeking the Index in this Manner by Diviſion of the Differences, the Quotient ought generally to be taken with the leaſt: but in the preſent Caſe it happens to be the moſt, becauſe inſtead of the Difference between 0, 8 and 1, we ought ſtrictly to have taken the Difference between the reciprocal 1, 25 and 1, which would have given the Index 10; and that would be too big, becauſe the Product by that Means would have been bigger than 1, as 1,024 is. Whereas this Approximation requires that the Numbers in the firſt Column be alternately greater and leſs than 1, as may be ſeen in the Table.

When I have in this Manner continued the Calculation, till I have got the Numbers ſmall enough, I ſuppoſe the laſt Logarithm to be equal to nothing. Which gives me an Equation, from which having got away the Letters by Means of the foregoing Equations, I have the Relation of the Logarithms propoſed. In this Manner if I ſuppoſe $G = 0$, I have $2136\,l\,2 - 643\,l\,10 = 0$. Which gives the Logarithm of 2 true in ſeven Figures, and too big in the Eighth; which happens becauſe the Number correſponding with G is bigger than Unit.

There is another Expedient which renders this Calculation ſtill ſhorter. It is founded upon this Conſideration, that when x is very ſmall $\overline{1+x}|^{n}$ is very nearly $1 + nx$. Hence if $1 + x$, and $1 - z$ are the two laſt Numbers already got in the firſt Column of the Table, their Powers $\overline{1+x}|^{m}$ and $\overline{1-z}|^{n}$ are ſuch as will make the Product $\overline{1+x}|^{m} \times \overline{1+z}|^{n}$ very near to Unit, m and n may be found thus: $\overline{1+x}|^{m} = \overline{1+mx}$ and $\overline{1-z}|^{n} = 1 - nz$, and conſequently $\overline{1+x}|^{m} \times \overline{1-z}|^{n} = 1 + mx - nz - mnzx$, or (neglecting $mnzx$) $1 +$

mx

$m x - n z$. Make this equal to 1, and we have $m : n :: z : x :: l\overline{1-z} : l\overline{1+x}$. Whence $x l\overline{1-z} + z l\overline{1+x} = 0$. To give an Example of the Application of this, let 1, 024 and 0,990352 be the laſt Numbers in the Table, their Logarithms being C and D. Then we have $1{,}024 = 1 + x$, and $0{,}990352 = 1 - z$, and conſequently $x = 0{,}024$, and $z = 0{,}009648$. Whence the Ratio $\frac{z}{x}$ in the leaſt Numbers is $\frac{201}{500}$. So that for finding the Logarithms propoſed we may have $500\, D + 201\, C = 48510\, l\, 2 - 14603\, l\, 10 = 0$; which gives $l\, 2 = 0{,}3010307$, which is too big in the laſt Figure; but it is nearer the Truth than what is got from the Logarithm F ſuppoſed equal to nothing. So that by this Means we have ſaved four Multiplications, which were neceſſary to find the Number 9989595, &c. correſpondent to F, and which muſt have been had if we would make the Logarithm true to the ſame Number of Places without this *Compendium*.

1,280000000000	$A = 7\, l2 - 2\, l10$	$l2 > 0{,}28$
0,800000000000	$B = 3\, l2 - l10$	$< 0{,}33$
1,024000000000	$C = B + A = 10\, l2 - 3\, l10$	$> 0{,}300$
0,990352031429	$D = 9\, C + B = 93\, l2 - 28\, l10$	$< 0{,}30107$
1,004336277664	$E = 2\, D + C = 169\, l2 - 59\, l10$	$> 0{,}301020$
0,998959536107	$F = 2\, E + D = 485\, l2 - 146\, l10$	$< 0{,}3010309$
1,000162894165	$G = 4\, F + E = 2136\, l2 - 643\, l10$	$> 0{,}30102996$
0,999936281874	$H = 6\, G + F = 13301\, l2 - 4004\, l10$	$< 0{,}301029997$
1,000035441215	$I = 2\, H + G = 28738\, l2 - 8651\, l10$	$> 0{,}3010299951$
0,999971720830	$K = I + H = 42039\, l2 - 12655\, l10$	$< 0{,}3010299959$
1,000007161046	$L = K + I = 70777\, l2 - 21306\, l10$	$> 0{,}30102999562$
0,999993203514	$M = 3\, L + K = 254370\, l2 - 76573\, l10$	$< 0{,}30102999567$
1,000000364511	$N = M + L = 325147\, l2 - 97879\, l10$	$> 0{,}3010299956635$
0,999999764687	$O = 18\, N + M = 6107016\, l2 - 1838335\, l10$	$< 0{,}3010299956640$
Com. Ar. 235313		
$0 = 364511\, O +$	$235313\, N = 2302585825187\, l2 - 693147400972\, l10$	$> 0{,}3010299956639 87$

I have computed this Table ſo far, that the Reader may ſee in what Manner this Method approximates; this whole Work, as it appears, requiring a little more than three Hours Time.

Of the ſumming of Infinite Series, Part I. by *P. R.* de Monmort. n. 353. p. 633.

XVIII. 1 *Prop.* 1. *Prob.* To find the Sum of any Number of Terms of this Series.

$$a \times \overline{a+n} \times \overline{a+2n} \times \overline{a+3n} \times \overline{a+4n}, \text{ \&c. } \times \overline{a+\overline{p-1}\,n}$$
$$+\overline{a+n} \times \overline{a+2n} \times \overline{a+3n} \times \overline{a+4n}, \text{ \&c. } \times \overline{a+pn}$$
$$+\overline{a+2n} \times \overline{a+3n} \times \overline{a+4n}, \text{ \&c. } \times \overline{a+\overline{p+1}\,n}$$
$$+\overline{a+3n} \times \overline{a+4n}. \text{ \&c. } \times \overline{a+\overline{p+2}\,n}$$
$$+\overline{a+4n}, \text{ \&c. } \times \overline{a+\overline{p+3}\,n}$$
&c.

Here n is the given Difference both of the continued Factors a, $a+n$, $a+2n$, *&c.* of every the ſame Term, as of the homologous Factors of the ſucceſſive Terms of the Series continued; and p denotes the Number of ſuch Factors in every Term.

Solution. Let x denote the firſt of the Factors in the laſt of the Terms whoſe Sum is required; then that Sum will be

$$\frac{x \times \overline{x+n} \times \overline{x+2n}, \text{ \&c.} \times \overline{x+pn} - \overline{a-n} \times a \times \overline{a+n} \times \text{\&c.} \times \overline{a+\overline{p-1}\,n}}{\overline{p+1}\,n}$$

Q. E. I.

Example 1. Let the Series of natural Numbers be propoſed, $1+2+3+4$, *&c.* and let the Sum be found of ſo many Terms as there are Units in the Number z, which in this Caſe is alſo the laſt of the Terms whoſe Sum is required. Then in this Caſe it will be $a=1$, $n=1$, $p=1$, and $x=z$. whence $x \times \overline{x+n} \times$ *&c.* $\times \overline{x+pn} = z \times \overline{z+1}$, and $\overline{a-n} \times a \times$ *&c.* $\times \overline{a+\overline{p-1}\,n} = 0$, and $\overline{p+1}\,n = 2 \times 1$. Therefore the Sum required is $\frac{z \times \overline{z+1}}{2}$.

Example 2. In the Series $1+3+6+10$, *&c.* of Triangular Numbers, let the Sum of ſo many Terms be found as there are Units in the Number z. The Numbers in this Series may be wrote thus: $\frac{1\times2}{2}$, $\frac{2\times3}{2}$, $\frac{3\times4}{2}$, $\frac{4\times5}{2}$, *&c.* By this Means, if we ſet aſide the given Diviſor 2, the Series is reduced to the Form of the Propoſition, it being $a=1$, $n=1$, $p=2$, and $x=z$. Whence the double Sum of the Series is $\frac{x \times \overline{x+1} \times \overline{x+2} - 0}{3} = \frac{x \times \overline{x+1} \times \overline{x+2}}{3}$. And having Regard to the Diviſor 2, the Sum of the Series will be $\frac{x \times \overline{x+1} \times \overline{x+2}}{2 \times 3}$, or $\frac{z \times \overline{z+1} \times \overline{z+2}}{2 \times 3}$, in this Caſe x and z being the ſame. And after the ſame Manner the Sums of the other figurate Numbers may be found, whoſe Forms are now commonly known.

Example 3. Let $a = 1$, $n = 2$, $p = 3$, that the propoſed Series may be $1 \times 3 \times 5 + 3 \times 5 \times 7 + 5 \times 7 \times 9$, &c. In this Caſe the Form of the Sum is $\frac{x \times \overline{x+2} \times \overline{x+4} \times \overline{x+6} - \overline{1-2} \times 1 \times 3 \times 5}{4 \times 2} = \frac{x \times \overline{x+2} \times \overline{x+4} \times \overline{x+6} + 15}{8}$. For Inſtance, if the Sum of ten Terms is required, then $x = 19$, which is the tenth Term in the Series of Arithmetical Proportionals 1, 3, 5, 7, &c. and therefore the Sum is $\frac{19 \times 21 \times 23 \times 25 + 15}{8} = 28630$. Now the Propoſition is thus demonſtrated.

Demonſtration. Let there be a Series of Quantities, A, B, C, D, &c. whoſe Differences conſtitute the Series a, b, c, d, &c. ſo that it may be $a = B - A$, $b = C - B$, $c = D - C$, &c. Hence we immediately gather, that $a + b = C - A$, $a + b + c = d - A$, $a + b + c + d = E - A$; and in general, that the Aggregate of any Number of Terms of the Series a, b, c, d, &c. is equal to the next following Term of the Series A, B, C, D, &c. leſſen'd by the firſt Term A. For A, B, C, &c. take the Terms.

$\frac{\overline{a-n} \times a \times \&c. \times \overline{a+\overline{p-1}\,n}}{\overline{p+1}\,n}$, $\frac{a \times \overline{a+n} \times \&c. \times \overline{a+pn}}{\overline{p+1}\,n}$

$\frac{\overline{a+n} \times \overline{a+2n} \times \&c. \times \overline{a+\overline{p+1}\,n}}{\overline{p+1}\,n}$, &c. that is, the ſucceſſive Values of

$\frac{x \times \overline{x+n} \times \&c. \times \overline{x+pn}}{\overline{p+1}\,n}$; and their Differences being taken for a, b, c, d, &c. then will $a \times \overline{a+n}, \times$ &c. $\times \overline{a+\overline{p-1}\,n}$, $\overline{a+n} \times \overline{a+2n}, \times$ &c.

$\times\overline{a+pn}$, &c. which are the very Terms of the Series propos'd. But by comparing theſe Series, if any Term of the latter Series is $x\times\overline{x+n}\times$ &c. $\times\overline{x+\overline{p-1}\,n}$, it is plain that the Term one Step farther in the former Series will be $\frac{x\times\overline{x+n}\times\&c.\times\overline{x+pn}}{\overline{p+1}\,n}$. Therefore the Sum of the latter Series, as far as the Term $x\times\overline{x+n}\times$ &c. $\times\overline{x+\overline{p-1}\,n}$ incluſively, is

$$\frac{x\times\overline{x+n}\times\&c.\times\overline{x+pn}-\overline{a-n}\times a\times\&c.\times\overline{a+\overline{p-1}\,n}}{\overline{p+1}\,n}\quad Q.\,E.\,D.$$

Scholium 1. In this Propoſition is contain'd ſome little Part of the *Methodus Incrementorum*, concerning which two Years ago my very good Friend Dr. *Brook Taylor*, Secretary to the Royal Society at *London*, publiſh'd a Book. He that would know more of this Method ſhould conſult that Work. It is ſufficient for our Purpoſe to obſerve, how great an Affinity there is between this Method and the Method of Fluxions, or the Differential Method. For as in the Method of Fluxions, to find the Fluxion of x^m any Dignity of x, one Side is to be converted into the Fluxion $\dot{x}$, and the Quantity ariſing is to be multiply'd into m the Index of the Dignity, that the Fluxion ſought $m\dot{x}x^{m-1}$ may be produc'd; ſo in the Method of Increments, to find the Increment of ſuch a Product $x\times\overline{x+n}\times\overline{x+2n}$, (where the Factors x, $x+n$, $x+2n$, are in Arithmetical Progreſſion, whoſe common Difference is n the given Increment of x,) the leaſt of the Factors x is to be converted into the Increment, and the Quantity ariſing is to be multiply'd by the Number of the Factors, ſo that $3n\times\overline{x+n}\times\overline{x+2n}$ may be the Increment ſought, the Number of Factors in the Caſe propoſed being 3. Thus alſo the Increment of $x\times\overline{x+n}$ becomes $2n\times\overline{x+n}$.

2. Alſo by the ſame Rule are found the Increments of the Reciprocals of ſuch Products. But here it muſt be obſerved, that as Diviſion is contrary to Multiplication, inſtead of taking away the leaſt of the Factors, now another Factor muſt be added, which is greater ſtill by one Increment. Alſo that the Number of the Factors muſt be wrote with a

negative Sign. By this means the Increment of $\frac{1}{x}$ will be $\frac{-1\times n}{x\times\overline{x+n}}$

The Increment of $\frac{1}{x\times\overline{x+n}}$ will be $\frac{-2n}{x\times\overline{x+n}\times\overline{x+2n}}$. And ſo in all others of this Kind. This is eaſily proved by taking the Differences between two continued Values of the Integrals.

3. By treading in the Steps of the Direct Method, we may hence collect the Rules of the Inverſe Method, by which the Integrals of any given Increments are to be found. For let the given Increment be apply'd to the known Increment of the Side; let a Factor be added which is ſtill leſs by one Increment, and let the Quantity that ariſes be apply'd to the Number of the Factors ſo increaſed. Thus for Example, if the given Increment were $n\times x\times\overline{x+n}\times\overline{x+2n}$, it becomes firſt $x\times\overline{x+n}\times\overline{x+2n}$; then $\overline{x-n}\times x\times\overline{x+n}\times\overline{x+2n}$ adding the Factor $x-n$; laſtly, $\frac{\overline{x-n}\times x\times\overline{x+n}\times\overline{x+2n}}{4}$, which is the Integral required. This obtains when the Factors are Multipliers; but when the Factors are in the Place of Diviſors, then *mutatis mutandis* the Rule is thus. Let the given Increment be apply'd to the known Increment of the Side; let the greateſt of the Factors be rejected, and let the Quantity ariſing be apply'd to the Number of the Factors remaining with a negative Sign. For Example, let be given the Increment $\frac{n}{x\times\overline{x+n}\times\overline{x+2n}}$: Firſt it becomes $\frac{1}{x\times\overline{x+n}\times\overline{x+2n}}$, then $\frac{1}{x\times\overline{x+n}}$, laſtly, $\frac{1}{-2\times x\times\overline{x+n}}$ or $\frac{-1}{2\times x\times\overline{x+n}}$, which is the Integral required.

In this laſt Caſe the Integral found, with a contrary Sign, is equal to the Sum of all the Increments in the Series being continued to Infinity.

For Example it is $\frac{1}{2x\times\overline{x+n}}=\frac{n}{x\times\overline{x+n}\times\overline{x+2n}}$

+

$$+\frac{n}{\overline{x+n}\times\overline{x+2n}\times\overline{x+3n}}+\frac{n}{\overline{x+2n}\times\overline{x+3n}\times\overline{x+4n}},\ \&c.$$

For in this Caſe, x becoming at laſt infinite, $\frac{1}{2x\times\overline{x+n}}$ vaniſhes, that is, the laſt of the Terms *A*, *B*, *C*, *&c.* becomes nothing; and becauſe of the Contrariety of the Signs of the Integral and Increment, inſtead of $-A$ the Aggregate is expreſs'd by $+A$.

Lemma 1. In any Series of Numbers *M*, *N*, *O*, *P*, *&c.* let any Term be denoted by X, and let the Place of that Term in the Series be denoted by x; that is, let $x=1$, when X denotes the firſt Term or M; let $x=2$, when X denotes the ſecond Term N, and ſo on. And of the Terms *M*, *N*, *O*, *P*, *&c.* let b be the firſt of the firſt Differences, c the firſt of the ſecond Differences, d the firſt of the third, e the firſt of the fourth, and ſo on. Then it will be $X=M+b\times\frac{x-1}{1}+c\times\frac{x-1}{1}\times\frac{x-2}{2}+d\times\frac{x-1}{1}\times\frac{x-2}{2}\times\frac{x-3}{3}+e\times\frac{x-1}{1}\times\frac{x-2}{2}\times\frac{x-3}{3}\times\frac{x-4}{4}$, *&c.* This follows from the Table of Equations, *pag.* 66. of our Treatiſe call'd *Eſſay d'Analyſe*, &c.

Lemma 2. The ſame Things ſuppoſed, let any Term in the Series of Arithmetical Proportionals a, $a+n$, $a+2n$, *&c.* be denoted by z, and now let it be $X=A+Bz+Cz\times\overline{z+n}+Dz\times\overline{z+n}\times\overline{z+2n}+Ez\times\overline{z+n}\times\overline{z+2n}\times\overline{z+3n}$, *&c.* Then the Values of *A*, *B*, *C*, *D*, *E*, *&c.* will be theſe following.

$$A=M+b\times\frac{-a}{n}+c\times\frac{-a}{n}\times\frac{-a-n}{2n}$$

$$+d\times\frac{-a}{n}\times\frac{-a-n}{2n}\times\frac{-a-2n}{3n}$$

+

$$+e\times\frac{-a}{n}\times\frac{-a-n}{2n}\times\frac{-a-2n}{3n}\times\frac{-a-3n}{4n}, \text{\&c.}$$

$$B=\frac{1}{n}\times b+c\times\frac{-a-n}{n}+d\times\frac{-a-n}{n}\times\frac{-a-2n}{2n}$$

$$+e\times\frac{-a-n}{n}\times\frac{-a-2n}{2n}\times\frac{-a-3n}{3n}, \text{\&c.}$$

$$C=\frac{1}{n}\times\frac{1}{2n}\times c+d\times\frac{-a-2n}{n}+e\times\frac{-a-2n}{n}\times\frac{-a-3n}{2n}, \text{\&c.}$$

$$D=\frac{1}{n}\times\frac{1}{2n}\times\frac{1}{3n}\times d+e\times\frac{-a-3n}{n}, \text{\&c.}$$

$$E=\frac{1}{n}\times\frac{1}{2n}\times\frac{1}{3n}\times\frac{1}{4n}e, \text{\&c.}$$

The Order of forming the Coefficients of b, c, d, e, &c. in theſe Values, is ſufficiently manifeſt of itſelf.

Demonſtration. Becauſe by x and z the reſpective Terms of theſe Arithmetical Progreſſions are denoted, 1, 2, 3, 4, &c. and a, $a+n$, $a+2n$, $a+3n$, &c. therefore $x-1$ will denote the Number of the Differences n which is contain'd in z, ſo that it is $z=a+\overline{x-1}\,n$. Hence it is that $x-1=\frac{z-a}{n}$, $x-2=\frac{z-n-a}{n}$, $x-3=\frac{z-2n-a}{n}$, &c. Therefore by ſubſtituting theſe Values $x-1$, $x-2$, $x-3$, &c. in the Series of the foregoing Lemma, and reducing the Terms into Order, the Values of A, B, C, &c. come out as here exhibited.

Corol. When $a=n$, the Values of A, B, C, &c. become more ſimple, as

$A=M-b+c-d+e$, &c.

$B=$

$$B = \frac{1}{n} \times \overline{b - 2c + 3d - 4e, \&c.}$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times \overline{c - 3d + 6e, \&c.}$$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \overline{d + 4e, \&c.}$$

Lemma 3. The Symbols X and x being interpreted in the ſame Manner as in the firſt Lemma, let $q, r, s, t, u,$ &c. be the Generators of the Arithmetical Triangle, whoſe tranſverſe Line is occupy'd by the Series $M, N, O, P, Q,$ &c. but in an inverted Order, ſo that q ($= M$) may be the laſt Generator, r the laſt but one, s the laſt but two, and ſo on. Then it will be

$$X = q + r \times \frac{x-1}{1} + s \times \frac{x-1}{1} \times \frac{x}{2} + t \times \frac{x-1}{1} \times \frac{x}{2} \times \frac{x+1}{3}, \&c.$$

This is plain from the Conſideration of the Arithmetical Triangle itſelf, which we have exhibited *pag.* 63. of the Treatiſe *Eſſay d'Analyſe*, *&c.* where the ſame is more fully explain'd.

Lemma 4. The ſame Things being ſuppoſed, and the Symbol z being interpreted in the ſame Manner as in Lemma 2: If it is $X = A + Bz + Cz \times \overline{z+n}$, &c. as in *Lemma* 2. the Values of the Coefficients $A, B, C, D,$ &c. will be

$$A = q + r \times \frac{-a}{n} + s \times \frac{-a}{n} \times \frac{-a+n}{2n}$$

$$+ t \times \frac{-a}{n} \times \frac{-a+n}{2n} \times \frac{-a+2n}{3n}, \&c.$$

$$B = \frac{1}{n} \times r + s \times \frac{-a}{n} + t \times \frac{-a}{n} \times \frac{-a+n}{2n}, \&c.$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times s + t \times \frac{-a}{n}, \&c.$$

$D =$

$$D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times t, \text{&c.}$$

The Order of the Coefficients is manifeſt in theſe Values, and the Lemma is demonſtrated in the Manner of the ſecond Lemma.

Cor. 1. When $a = n$, the Coefficients *A*, *B*, *C*, *D*, *&c.* come out in ſimpler Forms thus.

$$A = q - r, \qquad B = \frac{1}{n} \times \overline{r - s},$$

$$C = \frac{1}{n} \times \frac{1}{2n} \times \overline{s - t}, \qquad D = \frac{1}{n} \times \frac{1}{2n} \times \frac{1}{3n} \times \overline{t - u}, \text{&c.}$$

Cor. 2. Whence if ſome of the Generators q, r, s, t, u, *&c.* are equal to one onother, *X* will be exhibited by a ſimpler Form, ſome of the Coefficients *A*, *B*, *C*, *&c.* vaniſhing.

Thus for Example, a Series of Numbers being propoſed 4, 69, 530, 2676, 10350, *&c.* which conſtitute the tenth tranſverſe Line in the Arithmetical Triangle, whoſe three firſt Generators are 54, — 18, 5, and the ſeven laſt are equal to 4; it being $a = 1 = n$; the Term *X* is exhibited by a Form of four Terms only,

$$-\frac{z}{1} \cdot \frac{z+1}{2} \cdot \frac{z+2}{3} \cdot \text{&c.} \times \frac{z+6}{7} + 23 \cdot \frac{z}{1} \cdot \frac{z+1}{2}, \text{&c.}$$

$$\times \frac{z+6}{7} - 72 \cdot \frac{z}{1} \cdot \frac{z+1}{2} \cdot \text{&c.} \times \frac{z+7}{8} + 54 \cdot \frac{z}{1} \cdot \frac{z+1}{2}$$

$\text{&c.} \times \frac{z+8}{9}$; the firſt ſix Coefficients *A*, *B*, *C*, *D*, *E*, *F*, vaniſhing.

Prop. 11. *Prob.* To find the Sum of any Number of Terms of this Series.

$$\frac{M}{a \times \overline{a+n}, \text{&c.} \times \overline{a+p-1}^{\,n}} + \frac{N}{\overline{a+n}, \text{&c.} \times \overline{a+p}^{\,n}}$$

$+\frac{O}{\overline{a+2n}, \text{\&c.} \times \overline{a+\overline{p+1}\,n}}$, *&c.* Where the Numerators *M*, *N*, *O*, *&c.* conſtitute any Series of Terms whoſe Differences are given, whether firſt, ſecond, third, *&c.* or which is the ſame, they conſtitute any tranſverſe Line in any given Arithmetical Triangle. But the Denominators conſtitute the Series exhibited in *Prop.* 1.

Solution. Let the firſt of the Factors a, $a+n$, $a+2n$, *&c.* be repreſented by X in the Denominator of the ſame Term, ſo that X and z may be the ſame as in the foregoing Lemma's; and therefore let any Term of the Series be repreſented by

$\frac{X}{z\times\overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-n}}}$. By Lemma 2 or 4, (as may ſeem convenient, either to admit the Differences, or the Generators of the Arithmetical Triangle,) let X be reſolved into the Multinomium $A+B\times z+Cz\times\overline{z+n}+Dz\times\overline{z+n}\times\overline{z+2n}$, *&c.* By this Means (the Terms of the Multinomium being apply'd to the Denominator $z\times\overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-n}}$,) every Term of the Series will be reduced to the Form $\frac{A}{z\times\overline{z+n}\ \text{\&c.} \times \overline{z+\overline{p-1}\,n}}$

$$+\frac{B}{\overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-1}\,n}}+\frac{C}{\overline{z+2n}, \text{\&c.} \times \overline{z+\overline{p-1}\,n}} \text{\&c.}$$

Whence (by *Schol.* 4. *Prop.* 1.) the Aggregate of the whole Series continued *in infinitum* from the Term $\frac{X}{z\times\overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-1}\,n}}$ incluſively, is $\frac{A}{\overline{p-1}\times n\times z\times\overline{z+n}\ \text{\&c.} \times \overline{z+\overline{p-2}\,n}}$

$$+\frac{B}{\overline{p-2}\times n\times\overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-2}\,n}}$$

$$+\frac{C}{\overline{p-}3\times n\times\overline{z+2n},\ \&c.\times\overline{z+p-2n},}\ \&c.$$

If this Aggregate be taken from the Value of the ſame Aggregate when $z=a$, the Remainder will be the Sum of all the Terms before the Term $\frac{X}{z+\&c.}$, that is, of ſo many Terms as there are Units in $\frac{z-a}{n}$.

Q, E. I.

Ex. 1. Let the firſt Example be the Series $\frac{5}{3\cdot5\cdot7\cdot9\cdot11\cdot13}$

$$+\frac{41}{5\cdot7\cdot9\cdot11\cdot13\cdot15}+\frac{131}{7\cdot9\cdot11\cdot13\cdot15\cdot17}$$

$$+\frac{275}{9\cdot11\cdot13\cdot15\cdot17\cdot19}+\frac{473}{11\cdot13\cdot15\cdot17\cdot19\cdot21},\ \&c.$$

'Tis here $a=3$, $n=2$, $p=6$, $M=5$. And taking the Differences of the Numerators, it will be $b=36$, $c=54$, $d=0=e=\&c.$ Hence in the ſecond Lemma 'tis $A=5+36\times\frac{-3}{2}+54\times\frac{-3}{2}\times\frac{-5}{4}=\frac{209}{4}$,

$B=\frac{1}{2}\times36+54\times\frac{-5}{2}=\frac{-99}{2}$, $C=\frac{1}{2}\times\frac{1}{4}\times54=\frac{27}{4}$,

$D=0=E=\&c.$ Therefore the Sum of the whole Series is

$$\frac{209}{4\times5\times2\times3\cdot5\cdot7\cdot9\cdot11}+\frac{-99}{2\times4\times2\times5\cdot7\cdot9\cdot11}$$

$+\frac{27}{4\times3\times2\times7\cdot9\cdot11}=\frac{283}{80\times3\cdot5\cdot7\cdot9\cdot11}$. And the Sum of the Terms in Number $\frac{z-3}{2}\left(=\frac{z-a}{n}\right)$ is $\frac{283}{80\times3\cdot5\cdot7\cdot9\cdot11}$ $=$

$$-\frac{209}{40\times z.\overline{z+2}.\overline{z+4}.\overline{z+6}.\overline{z+8}}+\frac{99}{16\times\overline{z+2}.\overline{z+4}.\overline{z+6}.\overline{z+8}}$$

$-\frac{27}{24\times\overline{z+4}.\overline{z+6}.\overline{z+8}}$. For Inſtance, let eight Terms be required; then it is $\frac{z-3}{2}=8$, or $z=19$; which Value being introduced into the Formula, the Sum is $\frac{155891}{2.3.3.3.3.5.5.5.7.11.19.23}$.

The ſame Numerators poſſeſs the third tranſverſe Line in the Arithmetical Triangle

54 . 54 . 54 . 54 . 54 . 54 . &c.
— 18 . 36 . 90 . 144 . 198 . &c.
5 . 41 . 131 . 275 . &c.

Whence in the Formula of *Lemma* 4. the Generators are $q=5$, $r=-18$, $s=54$, $t=0=$ &c. and the Coefficients come out $A=5-18\times\frac{-3}{2}+54\times\frac{-3}{2}\times\frac{-3+2}{4}=\frac{209}{4}$, $B=\frac{1}{2}\times\overline{-18+54\times\frac{-3}{2}}=\frac{-99}{2}$, $C=\frac{1}{2}\times\frac{1}{4}\times 54=\frac{27}{4}$, $D=0=E=$ &c. the ſame as above.

Ex 2. Let the Series be $\frac{4}{1.2.3.4.5.6.7.8.9.10.11}+\frac{69}{2.3.\&c.\,12}+\frac{530}{3.4.\&c.\,13}+\frac{2676}{4.5.\&c.\,14}+\frac{10350}{3.6.\&c.\,14}$ &c. where it is $a=1$, $n=1$, $p=11$, and the Numerators conſtitute the Series exhibited *Cor.* 20. *L.* 4. Therefore applying the Value of X in that *Corollary* to the Denominator $z\times\overline{z+1}$, &c. $\times\overline{z+10}$, the

Term of the propoſed Series becomes

$$\frac{-1}{1\cdot2\cdot3\cdot4\cdot5\cdot6\times\overline{z+6}\cdot\overline{z+7}\cdot\overline{z+8}\cdot\overline{z+9}\cdot\overline{z+10}}$$

$$+\frac{23}{1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\times\overline{z+7}\times\overline{z+8}\times\overline{z+9}\times\overline{z+10}}$$

$$-\frac{72}{1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\times\overline{z+8}\cdot\overline{z+9}\times\overline{z+10}}$$

$$+\frac{54}{1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\times\overline{z+9}\times\overline{z+10}}.$$

Therefore by this Propoſition the Sum of the Series continued from that Term *in infinitum*, is

$$\frac{-1}{4\times1\cdot2\cdot3\cdot4\cdot5\cdot6\times\overline{z+6}\times\overline{z+7}\times\overline{z+8}\times\overline{z+9}}$$

$$+\frac{23}{3\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\times\overline{z+7}\cdot\overline{z+8}\cdot\overline{z+9}}$$

$$-\frac{72}{2\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\times\overline{z+8}\times\overline{z+9}}$$

$$+\frac{54}{1\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\times\overline{z+9}}:$$

Therefore for z aſſuming 1, the Sum of the whole Series is

$$\frac{305}{12\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\cdot10}:$$

And in general, the Sum of the Terms in Number $\frac{z-1}{1}$ will be

$$\frac{305}{12\times1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\cdot10}$$

$+$

$$+\frac{1}{4\times1.2.3.4.5.6\times\overline{z+6}.\overline{z+7}.\overline{z+8}.\overline{z+9}}$$

$$-\frac{23}{3\times1.2.3.4.5.6.7\times\overline{z+7}.\overline{z+8}.\overline{z+9}}$$

$$+\frac{72}{2\times1.2.3.4.5.6.7.8\times\overline{z+8}\times\overline{z+9}}$$

$$-\frac{54}{1\times1.2.3.4.5.6.7.8.9\times\overline{z+9}}$$

Scholium 1. In computing the Sums of this Kind of Series, generally the Calculation is made eaſier by making Uſe of the Generators of the Arithmetical Triangle, than by making Uſe of the Differences. Therefore I have a Mind to take this Occaſion, to ſhew how the Generators of the Arithmetical Triangle may be found, from the Differences being given.

Therefore let *a* be the firſt Term of the Series, *a* the laſt Difference given, *b* the firſt of the laſt Order but one of the Differences, *c* the firſt of the next Order before, and ſo *d*, *e*, *&c.* and let *t*, *u*, *x*, *y*, *&c.* be the Generators of the Arithmetical Triangle required, whoſe tranſverſe Line in Order *p* is occupied by the Series propoſed. Then it is evident from the Conſideration of the Arithmetical Triangle, that

$$a=t,$$

$$b=\frac{p-1}{1}t+u,$$

$$c=\frac{p-1}{1}\times\frac{p-2}{2}t+\frac{p-2}{1}u+x,$$

$$d=\frac{p-1}{1}\times\frac{p-2}{2}\times\frac{p-3}{3}t+\frac{p-2}{1}\times\frac{p-3}{2}u$$

$$+\frac{p-3}{1}x+y,\ \&c.$$

Whence the Values of the Generators are collected,

$$t = a,$$

$$u = b - \frac{p-1}{1} t,$$

$$x = c - \frac{p-1}{1} \times \frac{p-2}{2} t - \frac{p-2}{1} u,$$

$$y = d - \frac{p-1}{1} \times \frac{p-2}{2} \times \frac{p-3}{3} t - \frac{p-2}{1} \times \frac{p-3}{2} u$$

$$- \frac{p-3}{1} x, \text{\&c.}$$

Now the laſt Generator is equal to a the firſt Term of the Series.

2. After I had communicated theſe Things to D. *de Monſoury*, he found another Solution of this Problem, the Formula of which I ſhall here ſet down, becauſe of its wonderful Simplicity. Therefore in the Series of Numerators let a be the firſt Term, b the firſt of the firſt Order of Differences, c the firſt of the ſecond, d the firſt of the third, and ſo on; and let the Denominator of the firſt Term be $z \times \overline{z+n}$, &c. $\times\, \overline{z + \overline{p-1}\, n}$. Then the Sum of the whole Series continued *in infinitum* will be exhibited by this Formula,

$$\frac{a}{n \times \overline{p-1} \times z \times \overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-2}\, n}}$$

$$+ \frac{b}{n^2 \times \overline{p-1} \times \overline{p-2} \times \overline{z+n}, \text{\&c.} \times \overline{z+\overline{p-2}\, n}}$$

$$+ \frac{c}{n^3 \times \overline{p-1} \times \overline{p-2} \times \overline{p-3} \times \overline{z+2n}, \text{\&c.} \times \overline{z+\overline{p-2}\, n}}, \text{\&c.}$$

Let us take an Example in the Series $\frac{5}{3 \cdot 5 \cdot \text{\&c.}\, 13} + \frac{41}{5 \cdot 7 \cdot \text{\&c.}\, 15}$ +

$+\frac{131}{7\cdot 9\cdot \&c.\ 17}+\frac{275}{9\cdot 11\cdot \&c.\ 19}$, &c. the Sum of which we have already exhibited. In this Caſe it is $a=5$, $b=36$, $c=54$, $d=0=e=$ &c. Whence by the Formula the Sum of the whole Series is $\frac{5}{2\cdot 5\times 3\cdot 5\ldots 11}+\frac{36}{4\cdot 5\times 4\cdot 5\ldots 11}+\frac{54}{8\cdot 5\cdot 4\cdot 3\times 7\ldots 11}=\frac{283}{80\times 3\cdot 5\ldots 11}$, as it was exhibited by our Formula. If it is required to find the Sum of the ſame Series beginning from the tenth Term $\frac{2273}{21\ldots 31}$, in this Caſe it is $a=2273$, $b=522$, $c=54$, and the Sum would be $\frac{2273}{2\cdot 5\times 21\ldots 29}+\frac{522}{4\cdot 5\cdot 4\times 23\ldots 29}+\frac{54}{8\cdot 5\cdot 4\cdot 3\times 25\ldots 29}$.

This Formula is very convenient, and exhibits the Sum with very little Trouble, as often as the Sum of the whole Series is required; for the Differences are not too many. But when the Differences are many, and the whole Series is not required, but only ſome of the initial Terms, then our Forms will be the more convenient.

3. When the Terms of the Series are formed only by Multiplication, and are not affected by variable Diviſors, the Sums may always be found by the Method delivered in *Prop.* 1. though the Formulæ are never ſo complicate: For they may always be reduced to ſuch Terms as that *Propoſition* requires. Thus if the Differences of z and x are m and n, and a Term in the Series is denoted by zx; this Term will be reduced to $\overline{a-nz}+\frac{n}{m}z\times\overline{z+m}$ whoſe Integral may be had by *Prop* 1. For becauſe $dx=n$ and $dz=m$, 'tis $dx=dz\times\frac{n}{m}$. And returning to the Integrals it will be $x=\frac{n}{m}z+a$, (the invariable Quantity a being

added, that an Account may be taken of the Relation between z and u in the firſt Term of the Series) which may be thus written, $\overline{a-n+\frac{n}{m}}\times\overline{z+m}$, that afterwards being drawn into z, it may acquire the neceſſary Form. And in the ſame Manner we may proceed in other Caſes of the ſame Kind. But when the Forms propoſed are affected with Diviſors, the ſame Difficulties occur as in the integral Calculus, as it is called, or in the inverſe Method of Fluxions, which are to be overcome with the ſame Induſtry. Nor can they always be overcome. For beſides as it hardly can be known for a Certainty what muſt be the Relation between the Numerator of the Fraction, and the Denominator, that the propoſed Formula may be reduced to an Integral; ſo it is often very difficult to find, whether ſuch a Relation is already in that Formula, or, if it is not, whether it can be introduced. What I have chiefly found of Uſe in this Matter, is contained in the three following *Propoſitions*,

Prop. III. *Prob.* The Quantities z, u, y, x, *&c.* increaſing by the given Differences n, m, l, o, *&c.* to find the Value of the integral Numerator N, ſo as that the Denominator being $z.\overline{z+n}$, *&c.* $\overline{z+pn}\times u.\overline{u+m}$, *&c.* $\overline{u+qm}\times y.\overline{y+l}$. *&c.* $\overline{y+rl}\times x.\overline{x+o}$. *&c*, $\overline{x+so}$, *&c.* the Fraction may be reduced to an Integral.

Solution. Make $N=\overline{z+pn}\times\overline{u+qm}\times\overline{y+rl}\times\overline{x+so}$, *&c.* $-zuyx$. *&c.* and the Integral will be a Fraction whoſe Denominator is $z.\overline{z+n}$. *&c.* $\overline{z+\overline{p-1}n}.u.\overline{u+m}$. *&c.* $\overline{u+\overline{q-1}m}.y.\overline{y+l}$ *&c.* $\overline{y+\overline{x-1}l}.\overline{x+o}$. *&c.* $\overline{x+\overline{s-1}o}$, *&c.* the Numerator being 1.

For the Difference of this Fraction is a Fraction whoſe Numerator is the exhibited Value of N, and the Denominator is the ſame rs the Denominator propoſed, as it ought to be.

Ex. 1. Let the Denominator propoſed be $z\times\overline{z+2}\times u\times\overline{u+3}$. In this Caſe Caſe 'tis $n=2$, $m=3$, $p=1$, $q=1$; Therefore $N=\overline{z+2}\times\overline{u+3}-zu=3z+2u+6$. And by $\frac{3z+2u+6}{z.\overline{z+2}\times u.\overline{u+3}}$ is repreſented a Term of a ſummable Series, the Sum of which, when continued *in infinitum*, is exhibited by $\frac{1}{zu}$. For Inſtance, let the firſt common Value of z and u be 1, and the Series to be ſum'd will be $\frac{1}{1\cdot3\times1\cdot4}+\frac{23}{3\cdot5\times4\cdot7}+\frac{35}{5\cdot7\times7\cdot10}$, *&c.* for the Sum of the whole is 1. By p let be denoted the Order of any Term in this Series, then it will be $p=\frac{z-1+2}{2}=\frac{u-1+3}{3}$, and therefore $z=2p-1$, and $u=3p-2$; which Values being ſubſtituted for z and u, the Term will be denoted by this Form $\frac{12p-1}{\overline{2p-1}\times\overline{2p+1}\times\overline{3p-2}\times\overline{3p+1}}$. But the Sum of all the Terms before this, that is, of the initial Terms which are $\frac{z-1}{2}=p-1$ in Number, will be $1-\frac{1}{zu}=\frac{zu-1}{zu}$; that is, $\frac{6pp-7p+1}{\overline{2p-1}\times\overline{3p-2}}$. Wherefore writing $p+1$ for p, the Aggregate of ſo many initial Terms as there are Units in p, will be

$$\frac{p\times\overline{6p+5}}{\overline{2p+1}\times\overline{3p+1}}.$$

Ex. 2. The ſame z, u, n, m ſtill remaining, let the Denominator be $z\cdot\overline{z+2}\cdot\overline{z+4}\times u\cdot\overline{u+3}$. Then by the Formula the Numerator will be $\overline{z+4}\times\overline{u+3}-zu=3z+4u+12$, and the Sum of the Series will be exhibited by the Formula $\frac{1}{z\cdot\overline{z+2}\times u}$. Of z and u let the firſt common Value be 1, and hence will be deduced the Series

$$\frac{19}{1\cdot3\cdot5\times1\cdot4}+\frac{37}{3\cdot5\cdot7\times4\cdot7}+\frac{55}{5\cdot7\cdot9\times7\cdot10}, \&c. = \frac{1}{1}.$$

Scholium. In the Series now exhibited there is every where the ſame Difference between the continual Factors of any the ſame Term, as between the homologous Factors of the continual Terms. In the following are ſome Examples of Series, whoſe Sums may be exhibited in a finite Number of Terms, although that Rule is not obſerved.

Prop. IV. *Prob.* The Quantity z increaſing by given Differences qn, to find the Integer Numerator N, ſo that the Fraction may be reduced to its Integral, whoſe Denominator conſiſts of a certain Number p of the Terms z, $z+n$, $z+2n$, &c. of Arithmetical Proportionals drawn into one another. But q muſt be an integer Number leſs than the Number of Factors p.

Solution. It will be $N = \overline{z+\overline{p-1}\,n} \times \overline{z+\overline{p-2}\,n}$. &c. $\times$ $\overline{z+\overline{p-q}\,n} - z \times \overline{z+n} \times$ &c. $\times \overline{z+\overline{q-1}\,n}$, the Integral being $\dfrac{1}{z \times \overline{z+n} \times \text{\&c.} \times \overline{z+\overline{p-q-1}\,n}}$. It is demonſtrated after the Manner of the foregoing Propoſition.

The Quantities n, p, q, being aſſumed at Pleaſure, and the firſt Value of z, hence will ariſe an infinite Number of ſummable Series, ſuch as the three following.

$$A = \frac{5}{1.2.3.4} + \frac{9}{3.4.5.6} + \frac{13}{5.6.7.8} + \frac{17}{7.8.9.10}, \text{ \&c.}$$

$$B = \frac{1}{1.2.3.4.5} + \frac{4}{4.5.6.7.8} + \frac{9}{7.8.9.10.11} + \frac{16}{10.11.12.13.14}, \text{ \&c.}$$

$$C = \frac{1}{1.2.3.4.5} + \frac{14}{5.6.7.8.9} + \frac{55}{9.10.11.12.13} +$$

$\frac{140}{13.14.15.16.17}$, &c.

I communicated theſe Series long ago to ſome principal Geometricians, to whom they did not ſeem contemptible. That very ſkilful Geometrician Mr. *Nicolas Bernoulli* thus writes to me in a Letter of *July* 25, 1716. "You will very much oblige me, Sir, if you will communicate to me the Solution of this Problem of yours. Having a Series of Fractions given, the Numerators of which are any figurate Number whatever, and of which the Denominators are formed of the Product of an equal Numbers of Factors which are in Arithmetical Progreſſion; to find their Sum. And chiefly how you have found theſe two Forms $\frac{p}{24\times\overline{4p+1}}$ and $\frac{p\times\overline{p+1}}{12\times\overline{3p+1}\times\overline{3p+2}}$.

Theſe Forms belong to the Series *C* and *B*, the Number of Terms whoſe Sum is required being denoted by *p*. And thus alſo Dr. *Taylor* writes to me, in his Letter of *Aug.* 22, 1716. "As alſo by what Method you fell upon the Summation of the Series exhibited by you, I mean chiefly of the Series $\frac{1}{1.2.3.4.5}+\frac{4}{4.5.6.7.8}+\frac{9}{7.8.9.10.11}$, which ſeems to be of a deeper Inquiry.

But now let us return to our Examples.

In the Series *A* 'tis $p=4$, $q=2$, $n=1$, the firſt Value of *z* being 1. Therefore 'tis $\overline{z+3}\times\overline{z+2}-z\times\overline{z+1}=2\times\overline{2z+3}$; whence (rejecting the given Number 2) are derived theſe Numerators 5, 9, 13, 17, &c. Alſo the Formula of the Sum is $\frac{1}{z\times\overline{z+1}}$. Then taking an Account of the Number 2, which we rejected out of the Numerators, the Sum of the whole Series, continued *in infinitum* from the Term in which is *z*, will be exhibited by the Formula $\frac{1}{2z.\times.\overline{z+1}}$; and therefore the Sum of the intire Series is $\frac{1}{2\times1\times2}=\frac{1}{4}$.

In the Series *B* 'tis $n = 1$, $p = 5$, $q = 3$, the firſt Value of z being 1. Therefore $N = \overline{z+4} \times \overline{z+3} \times \overline{z+2} - z \times \overline{z+1} \times \overline{z+2} = 6 \times \overline{z+2}|^2$. But the continued Values of $z+2$ are 3, 6, 9, &c. which becauſe they are all diviſible by 3, making $z+2 = 3x$, it will be $N = 6 \times \overline{3x}|^2 = 6 \times 9x^2 = 54x^2$, the continued Values of x being 1, 2, 3, &c. Therefore the given Number 54 being rejected, hence proceed the Numerators $1, 2^2, 3^2$, &c. that is, 1, 4, 9, &c. Alſo the integral Formula is $\dfrac{1}{z \times \overline{z+1}}$, wherefore taking Account of the Number 54 rejected out of the Numerators, the Sum of the Series continued *in infinitum* from the Term in which is z, will be $\dfrac{1}{54z \times \overline{z+1}}$. Whence the Sum of the intire Series is $\dfrac{1}{108}$.

Laſtly, in the Series *C* 'tis $n = 1$, $p = 5$, $q = 4$, and the firſt Value of z is 1. Whence $N = \overline{z+4} \times \overline{z+3} \times \overline{z+2} \times \overline{z+1} - z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} = 4 \times \overline{z+1} \times \overline{z+2} \times \overline{z+3}$. But the Values of N ariſing by this Formula can always be divided by $4 \times 2 \times 3 \times 4 = 96$. Therefore this Diviſor being rejected, there come out the Numerators 1, 14, 55, 140, &c. And the Formula of the Sum, admitting the Number 96, is $\dfrac{1}{96z}$. And therefore the Sum of the intire Series is $\dfrac{1}{96}$.

Scholium. By theſe two laſt Propoſitions we may eaſily find as many ſummable Series as we pleaſe. And on the contrary, having a Series given of this Kind, if it can be ſum'd its Sum may generally be reduced to one of theſe two Propoſitions. Yet there is Need of good Sagacity in the Tryal. But it proceeds beſt if the Terms of the given Series are reduced to the Form of *Prop.* III. Thus for Inſtance, having this Series propoſed $\dfrac{7}{3 \cdot 5 \cdot 7 \cdot 9 \cdot 11} + \dfrac{11}{7 \cdot 9 \cdot 11 \cdot 13 \cdot 15} + \dfrac{15}{11 \cdot 13 \cdot 15 \cdot 17 \cdot 19}$, &c. the Denominators may thus be written, $3 \cdot 7 \cdot 11 \times 5 \cdot 9$, $7 \cdot 11 \cdot 15 \times 9 \cdot 13$, $11 \cdot 15 \cdot 19 \times 13 \cdot 17$ &c. whence according to *Prop.* 3. 'tis $n = 4$, $m = 4$, $p = 2$, $q = 1$, the firſt Value of z is 3, the firſt Value of u is 5. Hence the Form of the Numerator is found to be $4 \times \overline{z + 2u + 8}$. But this is always diviſible by 3;

wherefore rejecting the given Diviſors 4 and 3, by this Formula the Numerators come forth, 7, 11, 15, &c. the ſame as the Numerators in the propoſed Series, which therefore may be ſum'd by that Propoſition.

2. After I had communicated thoſe Series *A*, *B*, *C*, to Dr. *Taylor*, he wrote me Word, that he had found their Sums, of the firſt *A* and the third *C* by reducing them to ſimple Caſes of his Method of Increments; that he had reduced the third *C* to this Form

$$\frac{1}{24}\times\overline{\frac{1}{1\cdot 5}+\frac{1}{5\cdot 9}+\frac{1}{9\cdot 13}+\frac{1}{13\cdot 17}},$$ &c. that the Sum might be had by the Precepts delivered in the *Scholium* of *Prop.* 1. But in the ſecond Series, *B*, when this did not ſucceed ſo well, he uſed the following Analyſis, which, becauſe of its great Elegance, having firſt obtained his Leave, I ſhall here inſert. "The Term of that Series (to uſe his own Notation) is exhibited by this Formula

$$\frac{\overline{z+2}\times\underset{.}{z}}{27z\times\overline{z+1}\times\underset{,}{z}\times\overline{\underset{,}{z}+1}};$$ writing in the Denominator $\underset{,}{z}$ for $z+3$, becauſe it is $\underset{.}{z}=3$. Suppoſe $\frac{B}{27C}$ to be equal to the Integral required, that is $\frac{B}{C}$ is the Integral of $\frac{\overline{z+2}\times\underset{.}{z}}{z\times\overline{z+1}\times\underset{,}{z}\times\overline{\underset{,}{z}+1}}$, ſetting aſide the given Diviſor 27. But the Increment of $\frac{B}{C}$ is $\frac{\underset{.}{B}C-B\underset{.}{C}}{C\underset{,}{C}}$. Therefore $\frac{\underset{.}{B}C-B\underset{.}{C}}{C\underset{,}{C}}$ and $\frac{\overline{z+2}\times\underset{.}{z}}{z\times\overline{z+1}\times\underset{,}{z}\times\overline{\underset{,}{z}+1}}$ ought to be the ſame. Then comparing the Denominators, it is found that $C=z\times\overline{z+1}$. And taking the Increments it becomes $\underset{.}{C}=2z\underset{.}{z}+\underset{.}{z}^2+\underset{.}{z}$ $(=2z\underset{.}{z}+4\underset{.}{z}$) becauſe it is $\underset{.}{z}=3$.) Theſe Values being ſubſtituted in the Place of C and $\underset{.}{C}$, there ariſes $\underset{.}{B}C-B\underset{.}{C}=\overline{zz+2}\,\underset{.}{B}-2\underset{.}{z}\times\overline{z+2}\,B$, which ought to be the ſame as $\overline{z+2}\times\underset{.}{z}$. Let $B=a+v$, a being the invariable Part of B, and v the variable Part. Then taking the Increments 'tis $\underset{.}{B}=\underset{.}{v}$. Whence to find a and v we have the Equation

$\overline{zz+z\underset{\cdot}{v}} - 2\underset{\cdot}{z} \times \overset{\cdot}{\overline{z+2}} \times \overline{a+v} = \overset{\cdot}{\overline{z+2}} \times \underset{\cdot}{z}$, which may thus be written $\overline{zz+z\underset{\cdot}{v}} - 2\underset{\cdot}{z} \times \overline{z+2}\, v = \underset{\cdot}{z} \times \overline{z+2} \times \overline{1+2a}$, or also $C\underset{\cdot}{v} - \underset{\cdot}{C}v = \underset{\cdot}{z} \times \overset{\cdot}{\overline{z+2}} \times \overline{1+2a}$. Make $1+2a=0$, (whence $a = \frac{-1}{2}$,) and it becomes $C\underset{\cdot}{v} - \underset{\cdot}{C}v = 0$, in which it may be $v = 0$, (because each Term of the Equation is affected either by v or $\underset{\cdot}{v}$,) hence it is $B = a = \frac{-1}{2}$, and therefore $\frac{B}{C} = \frac{-1}{2z \times \overline{z+1}}$. Then reſtoring the Diviſor 27, the Integral required will be $\frac{-1}{54 \times z \times \overline{z+1}}$. Now by comparing the Equation $C\underset{\cdot}{v} - \underset{\cdot}{C}v = 0$ with the general Formula $\frac{\underset{\cdot}{B}C - B\underset{\cdot}{C}}{C\underset{,}{C}} = 0$, we may thence conclude, that $\frac{v}{C}$ is equal to a given Quantity, becauſe its Increment is 0. So that aſſuming n for any given Number, it will be $v = n\underset{,}{C}$, and $B = -\frac{1}{2} + nC$. By which the Integral required becomes $\frac{B}{C} = \frac{-\frac{1}{2}+nC}{C} = \frac{-1}{2C} + n$; which differs from the Integral found before only by the given Quantity n. This proceeds from hence, that as in the Quadrature of Curves the Area when found may be increaſed or diminiſhed by a given Area, ſo in the Method of Increments, the Integral when found may be increaſed or diminiſhed by a given Quantity. But by the firſt Integral, where n is abſent, the Sum of the Series is exhibited when continued *ad infinitum*.

Prop. 5. When z increaſes by Units, and $a, b, c,$ &c. are given Quantities, none of which are equal to one another, to find the Integral of $\frac{1}{z \times \overline{z+a} \times \overline{z+b} \times \overline{z+c} \times \&c}$

Solution. Multiplying both the Numerator and Denominator of the Fraction into the Terms $z+1$, $z+2$, &c. $z+a+1$, $z+a+2$, &c.

z

$z+b+1, z+b+2$, &c. $z+c+1, z+c+2$, &c. deficient in the Denominator, let the Denominator be reduced to the Form $z\times\overline{z+1}\times\overline{z+2}$, &c. of the Denominator in *Prop.* 1. *Schol. n.* 3. Then let the Numerator be reduced to the Form $A+Bz+Cz\times\overline{z+1}+Dz\times\overline{z+1}\times\overline{z+2}$, &c. Then applying the Terms to the new Denominator $z\times\overline{z+1}\times\overline{z+2}$, &c. let the Fraction be reduced to this Form

$$\frac{A}{z\times\overline{z+1},\ \&c.}+\frac{B}{\overline{z+1}\times\overline{z+2},\ \&c.}+\frac{C}{\overline{z+2}\times\overline{z+3},\ \&c.}$$

$$+\frac{D}{\overline{z+3}\times\overline{z+4},\ \&c.},\ \&c.$$ whence laſtly let the Integral be ſought by *Schol. Prop.* 1. *n.* 3.

The Reaſon of the Solution is manifeſt of itſelf.

Scholium 1. The whole Difficulty of this Solution lies in the Reduction of the Numerator to the Form required, which yet how it may be done will appear from one Example. Therefore let the Product $\overline{z+2}\times\overline{z+3}\times\overline{z+7}$ be propoſed to be reduced to the required Form. Therefore I evolve the Terms by Degrees as follows. The firſt Factor $z+2$ I thus write $2+z$, whoſe firſt Term 2 I multiply into $3+x$, whence it becomes $6+2x$. The ſecond Term z I multiply by $2+\overline{z+1}$ $(=z+3)$ whence it is $2z+z\times\overline{z+1}$. Then collecting the Products it is $\overline{z+2}\times\overline{z+3}=\begin{matrix}6+2z\\+2z\end{matrix}+z\times\overline{z+1}=6+4z+z\times\overline{z+1}$. It remains to multiply this into $z+7$. Therefore I multiply the firſt Term 6 into $7+z$ $(=z+7)$ whence it is $42+6z$. I multiply the ſecond Term $4z$ into $6+\overline{z+1}$ $(=z+7)$ whence it is $24z+4z\times\overline{z+1}$; the third Term $z\times\overline{z+1}$ I multiply into $5+\overline{z+2}$ $(=z+7)$ whence it is $5z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}$. Therefore the Products being collected together as before 'tis $\overline{z+2}\times\overline{z+3}\times\overline{z+4}=42+30z+9z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}$. And ſo we may proceed in other Caſes.

2. Let us take an Example of the Propoſition in the Fraction $\frac{1}{z\times\overline{z+2}\times\overline{z+5}}$. By reſtoring the Factors $\overline{z+1}\times\overline{z+3}\times\overline{z+4}$,

which are deficient in the Denominator, the Fraction becomes

$$\frac{\overline{z+1}\times\overline{z+3}\times\overline{z+4}}{z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}\times\overline{z+5}}.$$

Therefore the Numerator is to be reduced to the Form required. Now by the Method already delivered, 'tis first $\overline{z+1}\times\overline{z+3}=1\times\overline{3+z}+z\times\overline{2+\overline{z+1}}$ $=3+\overline{z+2}\,z+z\times\overline{z+1}=3+3z+z\times\overline{z+1}$. Then $\overline{z+1}\times\overline{z+3}\times\overline{z+4}=3\times\overline{4+z}+3z\times\overline{3+\overline{z+1}}+z\times\overline{z+1}\times\overline{2+\overline{z+2}}=12+\overline{3z+9z+3z\times\overline{z+1}+2z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}}=12+12z+5z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}$. By applyiug this Product to the Denominator $z\times\overline{z+1}\times$ &c. $z+5$, the Fraction will be reduced at laſt to this Form

$$\frac{12}{z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}\times\overline{z+5}}+$$

$$\frac{12}{\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}\times\overline{z+5}}+$$

$$\frac{5}{\overline{z+2}\times\overline{z+3}\times\overline{z+4}\times\overline{z+5}}+\frac{1}{\overline{z+3}\times\overline{z+4}\times\overline{z+5}},$$

the Integral of which is $\dfrac{-12}{5z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}+$

$$\frac{-12}{4\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}+\frac{-5}{3\times\overline{z+2}\times\overline{z+3}\times\overline{z+4}}+$$

$$\frac{-1}{2\times\overline{z+3}\times\overline{z+4}}.$$

3. When there are two Factors only z and $z+a$, the Integral will alſo be exhibited by the Formula $\frac{1}{2} - \frac{1-a}{2z\times\overline{z+1}} - \frac{\overline{1-a}\times\overline{2-a}}{3z\times\overline{z+1}\times\overline{z+2}} - \frac{\overline{1-a}\times\overline{2-a}\times\overline{3-a}}{4z\times\overline{z+1}\times\overline{z+2}\times\overline{z+3}}$, &c. where the Series is to be continued till it breaks off by the vaniſhing of the Terms. If there are two Factors z and $z-a$, the Integral will be exhibited by the Formula $\frac{-1}{z-1} - \frac{-1+a}{2\times\overline{z-1}\times\overline{z-2}} - \frac{\overline{-1+a}\times\overline{-2+a}}{3\times\overline{z-1}\times\overline{z-2}\times\overline{z-3}}$, &c. The ſame Integral may be expreſs'd either Way, according as the Factor of the given Fraction is taken either leſs or greater than z.

4. If the firſt Value of z is $a+1$, the latter Formula will be changed into this $\frac{-1}{a}\times\frac{1}{1}\times\frac{1}{2}\times\frac{1}{3}$, &c. to $\frac{1}{a}$ incluſive, by which with a contrary Sign is exhibited the Sum of this Series continued *in infinitum*, $\frac{1}{1\times\overline{1+a}} + \frac{1}{2\times\overline{2+a}} + \frac{1}{3\times\overline{3+a}}$, &c. For Inſtance, let $a=1$, the Series will be $\frac{1}{1\times2} + \frac{1}{2\times3} + \frac{1}{3\times4}$, &c. $\times\frac{1}{1}\times\frac{1}{1} = 1$. If $a=2$, the Series will be $\frac{1}{1\times3} + \frac{1}{2\times4} + \frac{1}{3\times5}$ &c. $= \frac{1}{2}\times\overline{\frac{1}{1}+\frac{1}{2}} = \frac{3}{4}$. If $a=3$, the Series will be $\frac{1}{1\times4} + \frac{1}{2\times5} + \frac{1}{3\times6} + \frac{1}{4\times7}$, &c. $= \frac{1}{3}\times\frac{1}{1}+\frac{1}{2}+\frac{1}{3} = \frac{11}{18}$.

5. From the ~~ſame Series~~ $\frac{1}{1\times\overline{1+a}}+\frac{1}{2\times\overline{2+a}}+\frac{1}{3\times\overline{3+a}}$, *&c.* according to the different Values of a, ſeveral Series will ariſe, which in Form will be elegant enough. To ſet ſome of theſe before the Eye of the Reader, perhaps will not be unacceptable.

If the even Numbers 2, 4, 6, 8, *&c.* are made ſucceſſively equal to a, the Series will be as follows.

If $a=2$) $\frac{1}{1\times\overline{1+2}}+\frac{1}{2\times\overline{2+2}}+\frac{1}{3\times\overline{3+2}}+\frac{1}{4\times\overline{4+2}}$, *&c.*

4) $\frac{1}{1\times\overline{1+4}}+\frac{1}{2\times\overline{2+4}}+\frac{1}{3\times\overline{3+4}}+\frac{1}{4\times\overline{4+4}}$, *&c.*

6) $\frac{1}{1\times\overline{1+6}}+\frac{1}{2\times\overline{2+6}}+\frac{1}{3\times\overline{3+6}}+\frac{1}{4\times\overline{4+6}}$, *&c.*

8) $\frac{1}{1\times\overline{1+8}}+\frac{1}{2\times\overline{2+8}}+\frac{1}{3\times\overline{3+8}}+\frac{1}{4\times\overline{4+8}}$, *&c.*

Or $\frac{1}{4-1}+\frac{1}{9-1}+\frac{1}{16-1}+\frac{1}{25-1}$, *&c.*

$\frac{1}{9-4}+\frac{1}{16-4}+\frac{1}{25-4}+\frac{1}{36-4}$, *&c.*

$\frac{1}{16-9}+\frac{1}{25-9}+\frac{1}{36-9}+\frac{1}{49-9}$, *&c.*

$\frac{1}{25-16}+\frac{1}{36-16}+\frac{1}{49-16}+\frac{1}{64-16}$, *&c.*

Or $\frac{1}{4-1}+\frac{1}{9-1}+\frac{1}{16-1}+\frac{1}{25-1}$, *&c.*

$$\frac{1}{4+1}+\frac{1}{9+3}+\frac{1}{16+5}+\frac{1}{25+7},\ \&c.$$

$$\frac{1}{4+3}+\frac{1}{9+7}+\frac{1}{16+11}+\frac{1}{25+15},\ \&c.$$

$$\frac{1}{4+5}+\frac{1}{9+11}+\frac{1}{16+17}+\frac{1}{25+23},\ \&c.$$

If for a are taken the odd Numbers ſucceſſively, 1, 3, 5, 7, &c. the Series will be

$$a=1)\ \frac{1}{1\times\overline{1+1}}+\frac{1}{2\times\overline{2+1}}+\frac{1}{3\times\overline{3+1}}+\frac{1}{4\times\overline{4+1}},\ \&c.$$

$$3)\ \frac{1}{1\times\overline{1+3}}+\frac{1}{2\times\overline{2+3}}+\frac{1}{3\times\overline{3+3}}+\frac{1}{4\times\overline{4+3}},\ \&c.$$

$$5)\ \frac{1}{1\times\overline{1+5}}+\frac{1}{2\times\overline{2+5}}+\frac{1}{3\times\overline{3+5}}+\frac{1}{4\times\overline{4+5}},\ \&c.$$

$$7)\ \frac{1}{1\times\overline{1+7}}+\frac{1}{2\times\overline{2+7}}+\frac{1}{3\times\overline{3+7}}+\frac{1}{4\times\overline{4+7}},\ \&c.$$

$$\text{Or}\ \frac{1}{2}\times\frac{1}{1}+\frac{1}{3}+\frac{1}{6}+\frac{1}{10},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{3-1}+\frac{1}{6-1}+\frac{1}{10-1}+\frac{1}{15-1},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{6-3}+\frac{1}{10-3}+\frac{1}{15-3}+\frac{1}{21-3},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{10-6}+\frac{1}{15-6}+\frac{1}{21-6}+\frac{1}{28-6},\ \&c.$$

$$\text{Or}\ \frac{1}{2}\times\frac{1}{1+0}+\frac{1}{3+0}+\frac{1}{6+0}+\frac{1}{10+0},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{1+1}+\frac{1}{3+2}+\frac{1}{6+3}+\frac{1}{10+4},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{1+2}+\frac{1}{3+4}+\frac{1}{6+6}+\frac{1}{10+8},\ \&c.$$

$$\frac{1}{2}\times\frac{1}{1+3}+\frac{1}{3+6}+\frac{1}{6+9}+\frac{1}{10+12},\ \&c.$$

6. Some Years ago that great Geometrician Mr. *James Bernoulli* found the Sum of any Series, whoſe Numerators conſtitute a Series of Equals, and the Denominators were a Series of Squares diminiſh'd by any given Square *Q*, or a Series of Triangles diminiſh'd by any given Triangle *T*. This he found by obſerving, that ſuch Series ariſe, by taking away a truncated Series of harmonically Proportionals from the ſame Series when intire; that is, ſo that the Number of deficient Terms in the truncated Series may be either double of the Side of the given Square *Q*, or the double increaſed by Unity of the Side of the given Triangle *T*. He obſerved alſo, that the Sum of a reciprocal Series of Squares would be ſought after in vain. And the ſame is true alſo of the Reciprocals of Cubes, or of any other Powers of Numbers in Arithmetical Progreſſion. The Reaſon is, becauſe no Difference intercedes between the Factors of the Denominators, which is always required for ſuch Summations, as appears from the Method of taking the Differences explain'd in the *Scholium* of *Prop.* 1. For if the Sum required could be exhibited by any Formula, the Difference of that Formula would exhibit the Terms of the propoſed Series; but in ſuch a Difference the Denominator is always affected by the Factors which are different from one another; which becauſe it does not take Place in the aforeſaid Series, the Sums of ſuch Series cannot be had in finite Terms. Almoſt in the ſame Manner, by an Argument derived from *Prop.* 3, 4. it may be demonſtrated, that the Sums of Series cannot be exhibited in a finite Number of Terms, whoſe Numerators conſtitute a Series of Equals, but the Denominators conſiſt of a certain Number of Terms in Arithmetical Progreſſion, the greateſt Factor of every Term being leſs than the leaſt Factor in the Term next following, ſuch as is this Series $\frac{1}{1\cdot 2}+\frac{1}{3\cdot 4}+\frac{1}{5\cdot 6}+\frac{1}{7\cdot 8}$, &c.

7. Now I might give ſome Rules which I have contrived for certain ſingular Caſes; but this would lead us too far. It may ſuffice therefore to have explain'd the more general, and to take Notice at the ſame Time, that nothing would more conduce to the Improvement of this new Doctrine of Infinite Series, than if ſome very general Forms of Sums were digeſted in Order, from the Differences of which being computed by

the Rule above, Canons might afterwards be form'd of ſummable Quantities; juſt as is already done in the Integral Calculus, or what Sir *I. Newton* calls the Inverſe Method of Fluxions.

8. By reſtoring the Factors which are deficient in the Denominator, the preſent Problem might be reduced to *Prop.* 2. Alſo it might be propoſed in more general Terms, or for the Numerator might any Formula be taken, of which any Difference is given. Yet with this Condition, that the Dimenſions of the Denominator ſhould exceed the Dimenſions of the Numerator at leaſt by two, for otherwiſe the Sum of the Series could not be had in finite Terms. Let there be an Example of this in the Series $\frac{1}{1 \cdot 3 \cdot 5 \cdot 7} + \frac{4}{2 \cdot 4 \cdot 6 \cdot 8} + \frac{9}{3 \cdot 5 \cdot 7 \cdot 9} + \frac{16}{4 \cdot 6 \cdot 8 \cdot 10}$, &c. where the Numerators are the Squares of the natural Numbers. Then applying both the Numerators and Denominators to the natural Numbers, the Series will be reduced to a more ſimple Form $\frac{1}{3 \cdot 5 \cdot 7} + \frac{2}{4 \cdot 6 \cdot 8} + \frac{3}{5 \cdot 7 \cdot 9} + \frac{4}{6 \cdot 8 \cdot 10}$, &c. The natural Numbers 1, 2, 3, 4, 5, &c. being denoted by p, a Term of the Series will be repreſented by the Form $\frac{p}{\overline{p+2} \times \overline{p+4} \times \overline{p+6}}$, or by the Formula $\frac{z-2}{z \times \overline{z+2} \times \overline{z+4}}$ writing z for $p+2$. Now in proceeding from Term to Term, becauſe z is increaſed by Units, the deficient Factors $z+1$, $z+3$, are to be reſtored in the Denominator, and by this Means the Term of the Series will be reduced to this Form $\frac{\overline{z-2} \times \overline{z+1} \times \overline{z+3}}{z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4}}$. By the Method already explain'd in this Propoſition, the Numerator is reduced to $-6-6z-z \times \overline{z+1} + z \times \overline{z+1} \times \overline{z+2}$. Whence having Reſpect to the Denominator, the Term is reduced to this Form

$$\frac{-6}{z \times \overline{z+1} \,.\, \&c. \times \overline{z+4}} + \frac{-6}{\overline{z+1} \times \overline{z+2} \times \overline{z+3} \times \overline{z+4}} + \frac{-1}{\overline{z+2} \times \overline{z+3} \times \overline{z+4}} + \frac{1}{\overline{z+3} \times \overline{z+4}}.$$

Therefore by taking the Integral we ſhall find it

$$\frac{6}{4z \times \overline{z+1} \times \overline{z+2} \times \overline{z+3}} + \frac{6}{3 \times \overline{z+1} \times \overline{z+2} \times \overline{z+3}} +$$

$\frac{1}{2\times\overline{z+2}\times\overline{z+3}}+\frac{-1}{z+3}$; by which with a contrary Sign will be exhibited the Sum of the Series continued *in infinitum*, beginning from the Term $\frac{z-2}{z\times\overline{z+2}\times\overline{z+4}}$. Therefore the Sum of the whole Series beginning from the Term $\frac{1}{3\cdot5\cdot7}$ will be $\frac{31}{240}$.

If we had a Mind to proceed by *Prop.* 2. from the Formula $\overline{z-2}\times\overline{z+1}\times\overline{z+3}$ the firſt Numerators being collected, 24, 70, 144, 252, taking their Differences we ſhould have $46=b$, $28=c$, $6=d$, $e=0$ $=$ &c. *M* being 24; whence by *Lem.* 2. the Formula $-6-6z-z\times\overline{z+1}+z\times\overline{z+1}\times\overline{z+2}$ would ariſe, by which the Term is denoted as above. And proceeding by *Prop.* 2. the Sum is had.

Prop. 6. *Prob.* To find the Sum of any Number of Terms of a Series of Fractions, whoſe Numerators and Denominators make any two tranſverſe Lines in *Paſchal*'s Arithmetical Triangle; that is, whoſe Generators are Units.

Solution. Let the Order of the Series of Numerators in the Arithmetical Triangle be denoted by n, and let p be the Difference between the Order of the Numerators and Denominators, and let the Number of the Terms whoſe Sum is required be denoted by q. Then if the Denominators are of more Dimenſions than the Numerators, the Sum will be exhibited by the firſt Formula following. But if the Dimenſions of the Numerators are more than thoſe of the Denominators, the Sum will be exhibited by the ſecond Formula.

Formula I.

$$\frac{n+p-1}{p-1}-\frac{n\,.\,\overline{n+1}\,.\,\overline{n+2}\,.\,\&c.\,\overline{n+p-1}}{\overline{p-1}\times\overline{n+q}\,.\,\overline{n+q+1}\,.\,\&c.\,\overline{n+q+p-2}}$$

Formula II.

$$-\frac{n-p-1}{p+1}+\frac{\overline{q+n-1}\,.\,\overline{q+n-2}\,.\,\&c.\,\overline{q+n-p-1}}{\overline{p+1}\times\overline{n-1}\,.\,\overline{n-2}\,.\,\&c.\,\overline{n-p}}.$$

Ex. 1. Let it be propoſed to find the Aggregate of the ſix firſt Terms of the Series $\frac{1}{1}+\frac{4}{7}+\frac{10}{28}+\frac{20}{84}+\frac{35}{210}+\frac{56}{462}$, &c. where the Numerators conſtitute the fourth Line, and the Denominators the ſeventh, in the Arithmetical Triangle. Therefore it is $n=4$, $p=3$, $q=6$, and becauſe the Dimenſions of the Denominators exceed the Dimenſions of the Numerators, the Sum will be given by the firſt Formula; that is, $\frac{4+3-1}{3-1}-\frac{4\cdot5\cdot6}{\overline{3-1}\times\overline{4+6}\times\overline{4+7}}=3-\frac{6}{11}$ $=2\frac{5}{11}$.

Ex. 2. Let the Sum be required of the ſix firſt Terms of this Series, $\frac{1}{1}+\frac{7}{4}+\frac{28}{10}+\frac{84}{20}+\frac{210}{35}+\frac{462}{56}$, *&c.* the Terms of which are the Reciprocals of the Terms of the foregoing Series. 'Tis therefore $n=7$, $p=3$, $q=6$, and therefore by the ſecond Formula the Sum is $-\frac{3}{4}+\frac{12\cdot11\cdot10\cdot9}{4\times6\cdot5\cdot4}=24$.

Scholium 1. Two Years ago I communicated the Forms in this Propoſition, to thoſe learned Geometricians M. de *Moivre* and the *Bernoulli's*. They may eaſily be derived from the Precepts delivered in *Prop.* 1. We will take for Example the foregoing Series $\frac{1}{1}+\frac{4}{7}+\frac{10}{28}$, *&c.* The Place of the Term in this Series being denoted by p, the Term will be exhibited by the Formula $\frac{4\cdot5\cdot6}{\overline{p+3}\cdot\overline{p+4}\cdot\overline{p+5}}$; whence returning to the Integral, the Sum of the Series beginning from that Term will be exhibited by the Formula $\frac{4\cdot5\cdot6.}{2\times\overline{p+3}\times\overline{p+4}}$. Therefore taking 1 for p, the whole Series is $\frac{4\cdot5\cdot6}{2\cdot4\cdot5}$, $=3$, and the Sum of the ſix firſt Terms will be $3-\frac{4\cdot5\cdot6}{2\cdot10\cdot11}$, juſt as it was now exhibited by the Formula.

2. In the firſt Formula the Sum of the Series continued *in infinitum* is $\frac{n+p-1}{p-1}$, the other Part of the Formula now vaniſhing. But in the

Caſe of the ſecond Formula, the Sum is an infinite Quantity, whoſe Species, in reſpect of the infinite Number q, is exhibited by the other Part of the Formula, which in this Caſe becomes $\frac{q^{p+1}}{\overline{p+1}\times\overline{n-1}\,.\,\overline{n-2}\,.\,\&c.\,\overline{n-p}}$.

3. Concerning Series of this Kind, that great Geometrician Mr. *Leibnitz*, in a Letter of *May* 1716, wrote to me in the following Manner: The Death of which great Man, lately taken from us, we now lament.

“ It ſeems to me that heretofore I ſum'd certain Series of this Kind,
“ ſuch as $\frac{1}{1}+\frac{2}{4}+\frac{3}{10}+\frac{4}{20}+\frac{5}{35}+\frac{6}{56}$, *&c.* The Term of this
“ Series expreſs'd Analytically is
“ $\frac{x}{x\,.\,\overline{x+1}\,.\,\overline{x+2}\times\frac{1}{1}\cdot\frac{1}{2}\cdot\frac{1}{3}}=\frac{1\,.\,2\,.\,3}{\overline{x+1}\,.\,\overline{x+2}}=\frac{6}{xx+3x+2}$.
“ 'Tis required to find the Sum of a given Series, one of the Terms of
“ which is $\frac{ll}{xx+3lx+2ll}$, where x ſignifies the natural Numbers
“ 1, 2, 3, *&c.* and l ſignifies Unity, or the Difference of the ſeveral x.
“ Let us ſuppoſe that the Term required of the Summing Series is
“ $\frac{fx}{mx+nl}=\frac{\odot}{\rightmoon}$. But the Difference of $\frac{\odot}{\rightmoon}=.\,\frac{-\odot}{\rightmoon}+\frac{\odot+d\odot}{\rightmoon+d\rightmoon}=$
“ $\frac{\rightmoon\,d\odot-\odot\,d\rightmoon}{\rightmoon\rightmoon+\rightmoon\,d\rightmoon}$. But $d\odot=fdx$, and $d\rightmoon=mdx=ml$. Therefore
“ the Difference of $\frac{\odot}{\rightmoon}=\frac{nfll}{\begin{array}{c}mmxx+2mnlx+nnll\\+mmlx+mnll\end{array}}$. Now we muſt make

$$\frac{nfll}{\begin{array}{c}mmxx+2mnlx+nnll\\+mmlx+mnll\end{array}}=\frac{mfll}{mmxx+3mmlx+2mmll},$$

that is
“ theſe two Forms muſt be identified, wherein the given Quantity is multi-
“ ply'd by $\frac{nf}{mm}$. Then making the reſpective Terms equal, ſince the
“ x's are the ſame, we ſhall have by ſimple x, $2n+m=3m$, that is to
“ ſay, $m=n$. Then by the abſolute Terms $nn+mn=2mm$, which
“ is again $m=n$. Therefore the Identification ſucceeds, and we may
“ make $n=m=l=1$, and $f=1$, (for f may be taken at Pleaſure) and

“ the Term of the Summing Series will be $\frac{x}{x+1}$. For the Difference of $\frac{x}{x+1}$ gives $-\frac{x}{x+1}+\frac{x+1}{x+2}=\frac{1}{xx+3x+2}$, and conſequently $\frac{6x}{x+1}$ gives the Sum of the $\frac{2}{x\cdot\overline{x+1}\cdot\overline{x+2}\times\frac{1}{1}\cdot\frac{1}{2}\cdot\frac{1}{3}}$, 3, 4, $\frac{9}{2}$, $\frac{24}{5}$, 5, $\frac{36}{7}$, &c. the Summing Series whoſe Term is $\frac{6x}{x+1}$. Alſo $\frac{1}{1}+\frac{2}{4}+\frac{3}{10}+\frac{4}{20}+\frac{5}{25}$, &c. is the Series to be ſum'd, whoſe Term is $\frac{x}{x\cdot\overline{x+1}\cdot\overline{x+2}\cdot\times\frac{1}{1}\times\frac{1}{2}\times\frac{1}{3}}$. And to make Uſe of them for Summations, the five Terms, for Example, of the given Series ſhall be $\frac{36}{7}-3=\frac{15}{7}$. And in general, the Sum of the Terms as far as any Term $\frac{x}{x\cdot\overline{x+1}\cdot\overline{x+2}\times\frac{1}{1}\times\frac{1}{2}\times\frac{1}{3}}$ excluſively, ſhall be $\frac{6x}{x+1}-3$. And for the Sum of the intire Series *ad infinitum*, x then becomes infinite, and therefore $\frac{6x}{x+1}=6$: Therefore the Sum of the whole Series is $6-3=3$, as you have found it.

“ This Method is the Calculation of Differences apply'd to Numbers; and I muſt own to you, that before I apply'd it to Figures, and even before I commenced Geometrician, I practiſed it in ſome Meaſure upon Numbers: Having found, when I was yet but young, that Series whoſe Numerators are Units, and the Denominators any figurate Numbers, as Triangular, Pyramidal, &c. were the firſt, ſecond, third, &c. Differences multiply'd by the conſtant Quantities of this Series $\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}$, &c. and conſequently were ſummable. But after I became ſomething of a Geometrician and an Analyſt, I ſaw it was poſſible to arrive at theſe Summations by a general Method, when it could be done; and that the Calculus of Differences was ſtill more convenient in Geometry than in Numbers, becauſe

" there are more frequent Coincidences, and that the Differences have " Place in the Tangents, as the Sums have in Quadratures. This ge- " neral Method of finding the Summing Series of the Series given, " when it is poſſible, always ſucceeds, when the Term of the Series " given expreſs'd Analytically has no variable Quantity involved in a " Radical Sign, nor entring in the Exponent; and then one may al- " ways determine the Summing Series, or prove it impoſſible to be " found. And the Thing very often ſucceeds, even when the variable " Quantity enters the Exponent. But as there are ſometimes particular " Quadratures of ſome Portions of a Figure, when one cannot give the " general Quadrature, or the Quadratrix; ſo ſometimes one may find " the Sum of the whole Series, or of a certain Part, though one cannot " find the Sum of every Part. Then we muſt have Recourſe to parti- " cular Methods, which we have not always in our Power, our Analy- " ſis being not yet carried to its due Perfection.

Prop. 7. *Prob.* To find the Sum of a Series, whoſe Numerators conſtitute any erect Line in *Paſchal's* Arithmetical Triangle, and the Denominators conſtitute any tranſverſe Line.

Solution. Let p denote the Order of the erect Line, and q the Order of the Tranſverſe Line; and let m be the Aggregate of ſo many of the firſt Terms in the erect Line of the Order $p + q - 1$ as there are Units in $q - 1$; and the Sum required will be $\overline{2^{p+q-2} - m} \times$

$$\frac{1 \cdot 2 \cdot 3 \cdot \&c. \overline{q-1}}{p \cdot \overline{p+1} \cdot \&c. \overline{p+q-2}}.$$

Ex 1. Let this Series be propoſed $\frac{1}{1} + \frac{5}{4} + \frac{10}{10} + \frac{10}{20} + \frac{5}{35} + \frac{1}{56}$, where the Numerators conſtitute the ſixth erect Line, and the Denominators poſſeſs the fourth tranſverſe Line. Therefore in this Caſe 'tis $p = 6$, $q = 4$, $p + q - 1 = 9$, $q - 1 = 3$, and therefore $m = 1 + 8 + 28 = 37$, that is, equal to the three firſt Terms of the ninth erect Line. Whence the Sum required will be $\overline{2^{8} - 37} \times \frac{1 \cdot 2 \cdot 3}{6 \cdot 7 \cdot 8} = \frac{219}{56}$.

Ex. 2. Let the Numerators conſtitute the hundredth erect Line, and let the Denominators be the Trigonal Numbers, which poſſeſs the third tranſverſe Line. Then it will be $p = 100$, $q = 3$, $m = 102$, and therefore the Sum required is $\overline{2^{101} - 102} \times \frac{1 \cdot 2}{100 \cdot 101}$.

Cor. If $q = 2$, the Formula becomes $\frac{2^{p} - 1}{p}$, by which the Aggregate will be exhibited, of the whole firſt Term, with half the ſecond, a third Part of the third, a fourth Part of the fourth, and ſo on, of any erect Line of the Order p of *Paſchal's* Arithmetical Triangle. Thus for Inſtance, $\frac{1}{1}+\frac{5}{2}+\frac{10}{3}+\frac{10}{4}+\frac{5}{5}+\frac{1}{6}=\frac{2^6-1}{6}=10\frac{1}{2}$.

Prop. 8. *Prob.* To find the Sum of the ſame Series, when the Signs of the Terms are alternately + and —.

Solution. The Sum required will be exhibited by this very ſimple Formula, $\frac{q-1}{p+q-2}$.

Ex. Let it be propoſed to find the Sum of this Series, $\frac{1}{1}-\frac{6}{9}+\frac{15}{45}-\frac{20}{165}+\frac{15}{495}-\frac{6}{1287}+\frac{1}{3003}$, where the Numerators conſtitute the ſeventh erect Line, and the Denominators the ninth tranſverſe Line. Therefore in the Formula for p and q writing 7 and 9, and the Sum will be $\frac{8}{14}=\frac{4}{7}$.

The ſame Series of Numerators remaining, (that is, the ſeventh erect Line) if for the Series of Denominators be taken the ſecond, third, fourth, &c. tranſverſe Lines ſucceſſively, the Sums will be $\frac{1}{7}$, $\frac{2}{8}$, $\frac{3}{9}$, $\frac{4}{10}$, $\frac{5}{11}$, &c. which may be wrote thus, $\frac{1}{7}$, $\frac{7}{28}$, $\frac{28}{84}$, $\frac{84}{210}$, $\frac{210}{462}$, &c. where both the Numerators and Denominators are taken out of the tranſverſe Line of the ſeventh Order. The ſame would obtain if inſtead of the ſeventh, the Numerators ſhould conſtitute any other erect Line of the Order p. For the Sums would ariſe from the Application of the Terms of the tranſverſe Line of the ſame Order p to the Terms next following in the ſame Line.

Theſe two laſt Propoſitions are rather neat than uſeful; therefore we will leave the Demonſtration of our Formulæ, to be found by the Ingenuity of the Reader, and betake ourſelves now to the laſt Propoſition, which contains a third Species of Series, remarkable enough for its great Uſe.

Lemma 5. Let there be any Series $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, $\frac{P}{b^4}$, &c. the Denominators of whoſe Terms conſtitute any Geometrical Progreſſion, b, b^2,

b^2, b^3, b^4, &c. Alſo let the firſt of the Numerators A ($= M$) be the firſt of the firſt Differences B, the firſt of the ſecond C, the firſt of the third D, of the fourth E, and ſo on. And let $\frac{\alpha}{b}$, $\frac{\beta}{b^2}$, $\frac{\gamma}{b^3}$, $\frac{\delta}{b^4}$, &c. reſpectively be the Aggregates of one, two, three, four, or more Terms of the Series $\frac{M}{b}$, $\frac{N}{b^2}$, $\frac{O}{b^3}$, &c. and let the firſt of the Numerators be a ($= \alpha$) the firſt of the firſt Differences be b, the firſt of the ſecond c, the firſt of the third d, and ſo on. And let $b - 1 = q$. Then the Values of a, b, c, d, &c. will be

$$a = A = \alpha = M$$
$$b = bA + B$$
$$c = qbA + bP + C$$
$$d = q^2 bA + qbB + qbC + D, \text{ and ſo on.}$$

Demonſtration. It is plain that $a = \alpha = A = M$.

The Terms $\frac{M}{b}$, $\frac{N}{b^2}$. $\frac{O}{b^3}$, $\frac{P}{b^4}$, &c. (the Numerators M, N, O, P, &c. being expreſs'd by A, B, C, D, &c.) are transform'd into the Terms $\frac{A}{b}$, $\frac{A+B}{b^2}$, $\frac{A+2B+C}{b^3}$, $\frac{A+3B+3C+D}{b^4}$, &c.

Whence by collecting the Sums of the Terms are found the Numerators α, β, γ, δ, &c. that is,

$$\alpha = A$$
$$\beta = \overline{b+1}A + B$$
$$\gamma = \overline{b^2+b+1}A + \overline{b+2}B + C$$
$$\delta = \overline{b^3+b^2+b+1}A + \overline{b^2+2b+3}B + \overline{b+3}C + D, \text{ \&c.}$$

Whence taking the Differences, they become

$$b = bA + B$$
$$c = qbA + bB + C$$
$$d = qqbA + qbB + bC + D, \text{ and ſo on, as in the Propoſition.}$$

Cor. 1. Of the Numerators M, N, O, P, &c. if the firſt, ſecond, third, or any other Difference is given; in the Series A, B, C, D, &c. all the Terms after ſome of the firſt vaniſhing, the Differences b, c, d, &c. will at laſt become a Geometrical Progreſſion in the Ratio of 1 to q. For Example, of the Numerators M, N, O, P, &c. if the firſt Difference B is given, then c, d, &c. will be in the continued Geometrical Ratio of 1 to q; as appears by their Values $qbA + bB$, $qqbA + qbB$, &c. it being $C = 0 = D$, &c.

Cor. 2. But the Order of the firſt of the Differences B, C, D, *&c.* which vaniſh in this Manner, is the ſame as the Order of the Differences b or c, *&c.* whence that Geometrical Progreſſion begins. Thus if $B = 0 = C$, *&c.* then b, c, d, *&c.* will be in a Geometrical Progreſſion. If $C = 0 = D$, *&c.* then c, d, *&c.* will be in a Geometrical Progreſſion. And ſo on.

Lemma 6. The ſame Things being ſuppoſed, let r be that Term by which the Geometrical Progreſſion begins in the Series of Differences b, c, d, *&c.* and by $p + 1$ let the Order in the Term be denoted in the Series $\frac{\alpha}{b}$, $\frac{\beta}{b^2}$, $\frac{\gamma}{b^3}$, $\frac{\delta}{b^4}$, *&c.* Then that Term will be denoted by a Fraction, the Denominator of which being b^{p+1}, the Numerator is

$$\frac{a + bp + cp \times \frac{p-1}{2} + dp \times \frac{p-1}{2} \times \frac{p-2}{3}, \text{\&c.} + \frac{r}{q^n}}{\times\, \overline{b^p - 1 - qp - q^2 p \times \frac{p-1}{2} - q^3 p \times \frac{p-1}{2} \times \frac{p-2}{3}, \text{\&c.}}}$$

the Order of the vaniſhing Difference of the Series B, C, D, *&c.* being denoted by n, as alſo the Number of the Terms $a + bp$, *&c.* and likewiſe of the Terms $-1 - qp$, *&c.*

Demonſtration. By *Lemma* 1, the Numerator of that Term is exhibited by the Formula $a + bp + cp \,.\, \frac{p-1}{2} + dp \times \frac{p-1}{2} \times \frac{p-2}{3}$, *&c.* (if $p + 1$ ſupplies the Place of x in that *Lemma.*)

Therefore if it is for Example $n = 2$, by *Lem.* 5. *Cor.* 2. it will be c, d, *&c.* in the continued Ratio of 1 to q. Therefore the Numerator in this Caſe is $a + bp + cp \times \frac{p-1}{2} + cqp \times \frac{p-1}{2} \times \frac{p-2}{3} + cq^2 p \times \frac{p-1}{2} \times \frac{p-2}{3} \times \frac{p-3}{4}$, *&c.* But if the Terms $cp \times \frac{p-1}{2} + cqp \times \frac{p-1}{2} \times \frac{p-2}{3}$, *&c.* are multiplied by $\frac{q^2}{c}$, and to the Product be added the Terms $1 + qp$, a Series will ariſe, by which the Dignity $\overline{1+q}|^{p} = b^{p}$ of the Binomial $1 + q$ is expreſs'd. Therefore that Product is equal to $b^p - 1 - qp$; and therefore the Terms $cp \times \frac{p-1}{2} + cqp \times \frac{p-1}{2} \times \frac{p-2}{3}$, *&c.* $= \frac{c}{q^2} \times \overline{b^p - 1 - qp}$, by which the Numerator becomes

comes $a + bp + \frac{c}{qq} \times \overline{b^p - 1 - qp}$; the two Terms being $a + bp$, as alſo the two $- 1 - qp$, according to the Senſe of the Propoſition, becauſe $n = 2$. And there is the ſame Demonſtration in other Caſes. As to the Denominator, the Thing is manifeſt of itſelf.

Prop. 9. *Prob.* To find the Sum of any Number of Terms of any Series $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}$, &c. of the Terms of which the Denominators conſtitute any Geometrical Progreſſion b, b^2, b^3, &c. and the Numerators are Quantities having any conſtant Difference.

Solution. Of the Numerators M, N, O, P, &c. let the firſt be A, the firſt of the firſt Differences B, the firſt of the ſecond C, the firſt of the third D, and ſo on. And of A, B, C, D, &c. let the Number be n, and $b - 1 = q$. Then let $a = A\ (= M)$ $b = bA + B$, $c = qbA + bB + C$, $d = q^2 bA + qbB + bC + D$, &c. that there may be ſo many Terms, a, b, c, &c. as there are Units in $n + 1$. Let the laſt of thoſe Terms be called r, and by $p + 1$ let the Number of Terms $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}$, be denoted, whoſe Sum is required. I ſay that Sum will be exhibited by a Fraction, whoſe Denominator being b^{p+1}, the Numerator will be

$$a + bp + cp \times \frac{p-1}{2} + dp \times \frac{p-1}{2} \times \frac{p-2}{3}, \&c. + \frac{r}{q^n}$$

$$\times \overline{\overline{b^p - 1 - qp - q^2 p \times \frac{p-1}{2} - q^3 p \times \frac{p-1}{2} \times \frac{p-2}{3}, \&c.}}$$

$$\overline{- q^{n-1} p \times \frac{p-1}{2}, \&c.}$$

Demonſtration. For (by *Lem.* 6.) by this Formula is repreſented the $p + 1$ Term in order of the Series $\frac{\alpha}{b}, \frac{\beta}{b^2}, \frac{\gamma}{b^3}, \frac{\delta}{b^4}$, &c. which Term (by the Conſtruction of *Lem.* 5.) is equal to the Aggregate of Terms in Number $r + 1$ of the propoſed Series $\frac{M}{b}, \frac{N}{b^2}, \frac{O}{b^3}, \frac{P}{b^4}$, &c. *Q. E. D.*

Ex. 1. Let there be found the Sum of nine Terms of the Series $\frac{1}{2}, \frac{2}{4}, \frac{3}{8}, \frac{4}{16}$, &c. In this Caſe 'tis $b = 2$, $q = b - 1 = 1$, $p + 1 = 9$, $p = 8$, $A = 1$, $B = 1$, $C = 0 = D$, &c. and therefore $n = 2$, (becauſe there are two, A, B,) Hence it is $a = A = 1$, $b = bA + B = 2 \times$

$1+1=3$, $c=qbA+bB+C=2\times 1+2\times 1+0=4=r$; and therefore by the Formula the Sum required is

$$\frac{1+3\times 8+\frac{4}{1^2}\times\overline{2^8-1-1\times 8}}{2^9}=\frac{1013}{512}.$$

Ex. 2. Let the Sum of ſix Terms be required of this Series $1\times 3+3\times 3^2+6\times 3^3+10\times 3^4+15\times 3^5+21\times 3^6$, *&c.* In this Caſe 'tis $b=\frac{1}{3}$, $q=\frac{-2}{3}$, $p+1=6$, $p=5$, $A=1$, $B=2$, $C=1$, $D=0=E$, *&c.* and therefore $n=3$, and $a=1$, $b=\frac{1}{3}+2=\frac{7}{3}$, $c=\frac{-2}{9}+\frac{2}{3}+1=\frac{13}{9}$, $d=\frac{4}{27}-\frac{4}{9}+\frac{1}{3}=\frac{1}{27}=r$. Whence the Sum required is 19956, or

$$\frac{1+\frac{7}{3}\times 5+\frac{13}{9}\times 5\times\frac{4}{2}+\frac{-1}{8}\times\overline{\frac{1}{3^5}-1+\frac{2}{3}\times 5-\frac{4}{9}\times 5\times\frac{4}{2}}}{\overline{\frac{1}{3}}\big|^{6}}.$$

Corol. 1. The Sum of the ſame Series, continued from the firſt Term $\frac{M}{b}$ *in infinitum*, is exhibited by a very ſimple Formula $\frac{A}{b-1}+\frac{B}{\overline{b-1}\big|^2}+\frac{C}{\overline{b-1}\big|^3}+\frac{D}{\overline{b-1}\big|^4}$, *&c.*

Corol. 2. If $b=2$, the Sum of the whole Series continued infinitely is had by the Addition only of the Terms A, B, C, D, *&c.* And this Sum is the ſame as the Sum of the erect Line anſwering to the firſt Term A in the Arithmetical Triangle, whoſe tranſverſe Line is occupied by the Numerators M, N, O, P, *&c.* which eaſily appears from the Conſideration of the Triangle. If therefore M, N, O, *&c.* are figurate Numbers of any Order n, the Sum of the Series $\frac{M}{2}+\frac{N}{4}+\frac{O}{8}+\frac{P}{16}$, *&c.* will be equal to this Dignity of the Number 2, that is $\overline{2}\big|^{n-1}$. Thus the Series $\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}$, *&c.* $2^{1-1}=1$, as is commonly known. The Series $\frac{1}{2}+\frac{2}{4}+\frac{3}{8}+\frac{4}{16}$, *&c.* $=2^{2-1}=2$; and the Series $\frac{1}{2}+\frac{3}{4}+\frac{6}{8}+\frac{10}{16}$ *&c.* $=2^{3-1}=2^2=4$. And ſo on.

Scholium. The celebrated Mr. *James Bernoulli*, in his Treatiſe about infinite Series, has ſolved this Problem. "To find the Sum of an infinite Series of Fractions, whoſe Denominators increaſe in any Geometrical Progreſſion, but the Numerators proceed either according to the natural Numbers 1, 2, 3, 4, *&c.* or Trigonals 1, 3, 6, 10, *&c.* or Pyramidals 1, 4, 10, 20, *&c.* or according to Squares 1, 4, 9, 16, *&c.* or Cubes 1, 8, 27, 64, *&c.* or the Multiples of theſe. The Reader may conſult his Solution. Mr. *Nic. Bernoulli* his Nephew found another Solution much more general, and was pleas'd to communicate it to me in a Letter of *September* 18, 1715, after I had ſent him this, but without a Demonſtration. His Letter was full of admirable Diſcoveries, ſuch as that learned Gentleman often imparts to me. Concerning this Problem he writes thus. As to the Sum of any determinate Number n of Terms of the Series of your ſeventh Theorem, (the firſt Corollary of this Propoſition) I have found this Formula $\frac{1}{m^n}\times$

$$\frac{n-1}{m-1}a+\frac{A-n}{m-1}b+\frac{B-n\,.\,\frac{n-1}{2}}{m-1}c+\frac{C-n\,.\,\frac{n-1}{2}\,.\,\frac{n-2}{3}}{m-1},\ d\ \&c.$$

where the Letters A, B, C, *&c.* denote the Coefficients of the Terms immediately preceding. And in this Formula putting $p+1$ for n, b^m for m, and multiplying the whole by e^{m-1}, we ſhall have the Solution of your *Prob.* 9. And this able Mathematician acquaints me, that this his general Formula will be changed into our particular one, (*Corol.* 1. of this *Propoſition*) when $n=\infty$. For then $1, n, n, \frac{n-1}{2}, n\,.\,\frac{n-1}{2}\,.\,\frac{n-2}{3}$, *&c.* will vaniſh in reſpect of the Terms m^n, A, B, C, *&c.* ſo that the Series in that Caſe will be $\frac{1}{m-1}a+\frac{A}{m-1}b+\frac{B}{m-1}c$, *&c.* which intirely coincides with ours $\frac{a}{m-1}+\frac{b}{\overline{m-1}^2}+\frac{c}{\overline{m-1}^3}$, *&c.*

Dr. *Taylor* has found another Solution of this Problem, very different from theſe by the Help of his Method of Increments. At the Deſire of that very learned Man I had ſent him my ſecond Formula for the Solution of *Prob.* 2. as alſo the other Forms belonging to the third, fourth, and fifth Propoſitions, but without their Demonſtrations. For I did not doubt but ſo acute a Man, and the Inventer of the Method of Increments, would be able to find out theſe, or others like to them. He wrote back that he had found the Solutions, and at the ſame Time communicated ſeveral other Things, tending much to the Improvement of this Method. Theſe, at my Requeſt, he has thought fit to ſubjoin to this Diſcourſe of mine.

An Appendix, *treating of the ſame Matter in a different Manner; by Dr.* B. Taylor, *ib. p.* 676.

At the Requeſt of the ingenious Author we exhibit the following Propoſitions, which we propos'd to reſerve for another Occaſion, but that we thought proper to comply with the Deſire of a Friend, who propoſed ſome of the foregoing Propoſitions to our Inquiry, and gave us the Occaſion of finding them.

Definitions. 1. I denote the preſent Value of any variable Quantity by the Letter ſimply wrote down, as x; the foregoing Values I diſtinguiſh by little Lines put at the Top of the Letter, and the following Values I diſtinguiſh by little Lines put under the Letter. So that by the Force of this Definition $\overset{\prime\prime}{x}, \overset{\prime}{x}, x, \underset{\prime}{x}, \underset{\prime\prime}{x}$, are five continual Values of the ſame variable Quantity, x being the preſent Value, $\overset{\prime}{x}$ the Value laſt paſt, $\overset{\prime\prime}{x}$ the ſecond paſt; $\underset{\prime}{x}$ is the Value next to come, and $\underset{\prime\prime}{x}$ the ſecond to come. And ſo of others. After the ſame Manner are to be underſtood the little Lines which are put to Increments. Thus $\underset{\cdot\cdot}{\overset{\prime\prime}{x}}, \underset{\cdot\cdot}{\overset{\prime}{x}}, \underset{\cdot\cdot}{x}, \underset{\prime\cdot\cdot}{x}, \underset{\prime\prime\cdot\cdot}{x}$, are five ſucceſſive Values of $\underset{\cdot\cdot}{x}$; and ſo $\underset{\cdot\cdot}{\overset{\prime\prime}{x}}$ is the ſecond Increment of $\overset{\prime\prime}{x}$, and $\underset{\cdot\cdot}{\overset{\prime}{x}}$ is the ſecond Increment of $\overset{\prime}{x}$; and the like of others.

Cor. By vertue of this Definition $\overset{\prime}{x} + \underset{\cdot}{\overset{\prime}{x}} = x$, $x + \underset{\cdot}{x} = \underset{\prime}{x}$, $\underset{\cdot}{x} + \underset{\cdot\cdot}{x} = \underset{\prime\cdot}{x}$. And ſo of all others of this Kind.

When Occaſion requires that a variable Quantity, ſuppoſe x, is to be look'd upon as an Increment, I denote its Integral by the Letter included between two Hooks [ ]. Alſo the Integral of the Integral [x] or the ſecond Integral of x. I denote by putting the Number 2 over the firſt of the Hooks, as $\overset{2}{[}\,x\,]$. Alſo the Integral of this Integral, or the third Integral of x, I denote in the ſame Manner by putting the Number

3 over the Hooks, as $\overset{3}{[x]}$. And ſo on. Therefore by virtue of this Definition $\overset{3}{[x]}$, $\overset{2}{[x]}$, $[x]$, x, conſtitute a Series of Terms, every one of which is the firſt Increment of the Quantity immediately before it; ſo that it is $\overset{2}{[x]} = \overset{3}{[\underset{\cdot}{x}]}$, $[x] = \overset{2}{[\underset{\cdot}{x}]}$, $x = [\underset{\cdot}{x}]$.

Lemma. The Increment of the Product $x\,v$, made by the Multiplication of the two variable Quantities x and v, is $\underset{\cdot}{x}\,v + \underset{\prime}{x}\,\underset{\cdot}{v}$.

For the Variables being increaſed by their proper Increments, becomes the new Product $\overline{x + \underset{\cdot}{x}} \times \overline{v + \underset{\cdot}{v}}$, or $x\,v + \underset{\cdot}{x}\,v + \overline{x + \underset{\cdot}{x}} \times \underset{\cdot}{v}$, that is, $x\,v + \underset{\cdot}{x}\,v + \underset{\prime}{x}\,\underset{\cdot}{v}$, writing $\underset{\prime}{x}$ for $x + \underset{\cdot}{x}$, by *Def.* 1. From whence taking the former Product $x\,v$, there remains the Increment $\underset{\cdot}{x}\,v + \underset{\prime}{x}\,\underset{\cdot}{v}$.

Prop. 1. *Theor.* The Increment of the ſame Product $x\,v$, either firſt, ſecond, third, or any other, the Order of which is denoted by the Symbol n, will be exhibited by this general Formula.

$$\underset{n}{x}\,v + n \times \underset{n-1}{\underset{\prime}{x}} \times \underset{\cdot}{v} + n \times \frac{n-1}{2} \times \underset{n-2}{\underset{\prime\prime}{x}} \times \underset{\cdot\cdot}{v} + n \times \frac{n-1}{2} \times \frac{n-2}{3} \times \underset{n-3}{\underset{\prime\prime\prime}{x}} \times \underset{\cdot\cdot\cdot}{v}, \text{ \&c.}$$

In this Formula theſe Things are to be obſerved. Firſt, the Coefficients of the Terms 1, n, $n \times \frac{n-1}{2}$, $n \times \frac{n-1}{2} \times \frac{n-2}{3}$, &c. are the ſame as of the Binomial raiſed to the Power n. Secondly, the Numbers n, $n-1$, $n-2$, &c. written below every x, denote the Number of the Points by which the Increments are determin'd. Thirdly, the little Lines $_{\prime}$, $_{\prime\prime}$, $_{\prime\prime\prime}$ &c. written under x, are to be interpreted according to *Def.* 1. Fourthly, in every Term the Number of the Points together written under x and v, always make n. For Inſtance, let $n = 4$, then by the Formula the fourth Increment of $x\,v$, will be $\underset{\cdot\cdot\cdot\cdot}{x}\,v + 4\,\underset{\cdot\cdot\cdot}{\underset{\prime}{x}}\,\underset{\cdot}{v} + 6\,\underset{\cdot\cdot}{\underset{\prime\prime}{x}}\,\underset{\cdot\cdot}{v} + 4\,\underset{\cdot}{\underset{\prime\prime\prime}{x}}\,\underset{\cdot\cdot\cdot}{v} + \underset{\prime\prime\prime\prime}{x}\,\underset{\cdot\cdot\cdot\cdot}{v}$.

Prop. 2. *Theor.* The firſt Integral of $x\,v$, or $[x\,v]$, is exhibited by the Series $[x]\,v - \overset{2}{[\underset{\prime}{x}]}\,\underset{\cdot}{v} + \overset{3}{[\underset{\prime\prime}{x}]}\,\underset{\cdot\cdot}{v} - \overset{4}{[\underset{\prime\prime\prime}{x}]}\,\underset{\cdot\cdot\cdot}{v}$, &c.

But the Series is thus terminated, that it may be $[xv] = [x]v -$

$$\left[\underset{\prime}{[x]}\underset{\cdot}{v}\right] = [x]v - \overset{2}{\underset{\prime}{[x]}}\,\underset{\cdot}{v}\ \left[\overset{2}{\underset{\prime\prime}{[x]}}\underset{\cdot\cdot}{v}\right] = \&c.$$

For by taking the Increments, the propoſed Quantity $x\ v$ will be reſtored.

Cor. 1. Two of thoſe $[x]$, $[x\,v]$, $\left[\underset{\prime}{[x]}\,\underset{\cdot}{v}\right]$, being given, the third will be given. Alſo any three of theſe being given $[x]$, $\overset{2}{\underset{\prime}{[x]}}$, $[x\,v]$, $\left[\overset{2}{\underset{\prime\prime}{[x]}}\,\underset{\cdot}{v}\right]$, the fourth is given; and ſo on.

Cor. 2. If $\underset{\cdot}{v} = 0$, then $[x\,v]$ is given when $[x]$ is given. If $\underset{\cdot\cdot}{v} = 0$, then $[x\,v]$ is given from the two $[x]$ and $\overset{2}{[x]}$ being given. If $\underset{\therefore}{v} = 0$, then $[x\,v]$ is given from the three $[x]$, $\overset{2}{[x]}$, $\overset{3}{[x]}$ being given. And ſo on.

Ex. 1. For an Example of this Formula, let us find the Integral of $\frac{v}{z\underset{\prime}{z}\underset{\prime\prime}{z}\underset{\prime\prime\prime}{z}}$ from $\underset{\cdot}{z}$ being given, and $\underset{\therefore}{v} = 0$; which is a particular Caſe of of the ſecond Propoſition of the foregoing Treatiſe of Mr. *Monmort*.

Making therefore $x = \frac{1}{z\underset{\prime}{z}\underset{\prime\prime}{z}\underset{\prime\prime\prime}{z}}$, 'tis $[x] = \frac{-1}{3\underset{\cdot}{z}z\underset{\prime}{z}\underset{\prime\prime}{z}}\ \overset{2}{\underset{\prime}{[x]}} = \frac{1}{2\underset{\cdot}{z}\times 3\underset{\cdot}{z}\underset{\prime}{z}\underset{\prime\prime}{z}}$

and $\overset{3}{\underset{\prime\prime}{[x]}} = \frac{-1}{1\underset{\cdot}{z}\times 2\underset{\cdot}{z}\times 3\underset{\cdot}{z}\underset{\prime\prime}{z}}$. Whence by the Formula it is $[x\,v]$,

that is $\left[\frac{v}{z\underset{\prime}{z}\underset{\prime\prime}{z}\underset{\prime\prime\prime}{z}}\right] = -\frac{v}{3\underset{\cdot}{z}z\underset{\prime}{z}\underset{\prime\prime}{z}} - \frac{\underset{\cdot}{v}}{2\underset{\cdot}{z}\times 3\underset{\cdot}{z}\underset{\prime}{z}\underset{\prime\prime}{z}} - \frac{\underset{\cdot\cdot}{v}}{1\underset{\cdot}{z}\times 2\underset{\cdot}{z}\times \underset{\cdot}{z}\underset{\prime\prime}{z}}$

Ex. 2. Let another Example be the Invention of the Integral of $z a^z$, where $\underset{\cdot}{z} = 1$, and a is given. Then for x aſſuming a^z, and for v taking z, 'tis $x = a^{\underset{\prime}{z}}$, that is $\underset{\prime}{x} = a\,x$, or $x + \underset{\cdot}{x} = a\,x$, and therefore $\underset{\cdot}{x} = \overline{a-1}$ x,

x, and $x = \frac{\underset{\cdot}{x}}{a-1}$. Therefore returning to the Integrals, it is $[x] = \frac{x}{a-1}$; alſo $\overset{2}{[x]} = \frac{[x]}{a-1} = \frac{x}{\overline{a-1}|^{2}}$. Alſo $\overset{3}{[x]} = \frac{x}{\overline{a-1}|^{3}}$; and ſo on. Therefore becauſe $\underset{\prime}{x} = a\,x$, 'tis $[x] = \frac{x}{a-1}$, $[\underset{\prime}{x}] = \frac{a\,x}{\overline{a-1}|^{2}}$, $[\underset{\prime\prime}{x}] = \frac{a^{2}\,x}{\overline{a-1}|^{3}}$, &c. Whence by the Formula there comes out $[n\,a^{n}]$ $= \frac{a^{n}\,n}{a-1} - \frac{a^{n+1}\,\underset{\cdot}{n}}{\overline{a-1}|^{2}} + \frac{a^{n+2}\,\underset{\cdot\cdot}{n}}{\overline{a-1}|^{3}}$, &c.

In this Example is contained the Solution of the Problem, treated of by Mr. *Monmort* in the ninth Propoſition. And the Formula coincides with that which he gives us in his firſt Corollary of the ſame Propoſition.

Scholium. Other Values alſo of the Integral required may be derived from this Form, according to the different Manner in which the Factors of the propoſed Increment are interpreted. Thus in the ſecond Example the Integral of $n\,a^{n}$ may be exhibited by the Formula $a^{n}[n] - \frac{}{a-1}\,a^{n}\overset{2}{[\underset{\prime}{n}]} + \overline{a-1}|^{2}\,a^{n}\overset{3}{[\underset{\prime\prime}{n}]}$, &c. that is, taking n for x, and a^{n} for v. But we may treat more of this perhaps on another Occaſion.

Prop. 3. *Theor.* The Integral of the ſame $x\,v$, either firſt, ſecond, third, or any other whoſe Order is denoted by the Symbol n, is exhibited by a Series proceeding in this general Form, $\overset{n}{[x\,v]} = \overset{n}{[x]}\,v - n\overset{n+1}{[\underset{\prime}{x}]}\,\underset{\cdot}{v} + n \times \frac{n+1}{2}\overset{n+2}{[\underset{\prime\prime}{x}]}\,\underset{\cdot\cdot}{v} - n \times \frac{n+1}{2} \times \frac{n+2}{3}\overset{n+3}{[\underset{\prime\prime\prime}{x}]}\,\underset{\therefore}{v}$, &c.

The Form of the Series being derived from the foregoing Propoſition, the Coefficients $1, -n, n \times \frac{n+1}{2} - n \times \frac{n+1}{2} \times \frac{n+2}{3}$, &c. are thus found by the Method of Increments. Suppoſe $\overset{n}{[x\,v]} = A\overset{n}{[x]}\,v + B\overset{n+1}{[\underset{\prime}{x}]}\,\underset{\cdot}{v} + C\overset{n+2}{[\underset{\prime\prime}{x}]}\,\underset{\cdot\cdot}{v} + D\overset{n+3}{[\underset{\prime\prime\prime}{x}]}\,\underset{\therefore}{v}$, &c. Then n being increaſed by its Augment $\underset{\cdot}{n} = 1$, and the Quantities A, B, C, D, &c. by their ſynchronal Increments $\underset{.}{A}, \underset{.}{B}, \underset{.}{C}, \underset{.}{D}$, &c. that they may now become, $\underset{\prime}{A}, \underset{\prime}{B}, \underset{\prime}{C}, \underset{\prime}{D}$, &c. a new Integral (which is the Integral of $\overset{n}{[xv]}$) will be had, that is $\overset{n+1}{[xv]} = \underset{\prime}{A}\overset{n+1}{[x]}v + \underset{\prime}{B}\overset{n+2}{[\underset{\prime}{x}]}\underset{.}{v} + \underset{\prime}{C}\overset{n+3}{[\underset{\prime\prime}{x}]}\underset{..}{v} + \underset{\prime}{D}\overset{n+4}{[\underset{\prime\prime\prime}{x}]}\underset{\vdots}{v}$, &c. Therefore the first Increment of this ought to coincide with the Integral supposed above. Therefore taking the Increments, it will be $\overset{n}{[xv]} =$

$$\underset{\prime}{A}\overset{n}{[x]}v + \underset{\prime}{A}\overset{n+1}{[\underset{\prime}{x}]}\underset{.}{v} + \underset{\prime}{B}\overset{n+2}{[\underset{\prime\prime}{x}]}\underset{..}{v} + \underset{\prime}{C}\overset{n+3}{[\underset{\prime\prime\prime}{x}]}\underset{\vdots}{v}, \text{ \&c.}$$
$$\qquad\quad + \underset{\prime}{B} \qquad\quad + \underset{\prime}{C} \qquad\quad + \underset{\prime}{D}$$

the same as the Integral above supposed. Therefore comparing the homologous Terms with one another, it is first $\underset{\prime}{A} = A$. Whence A is a given Quantity. But when $n = 0$, then $A = 1$; therefore $A = 1$. Secondly, $B = \underset{\prime}{B} + \underset{\prime}{A}$, that is, $B = B + B + 1$, or $B = -1 = -n$. Therefore returning to the Integrals it is $B = -n + a$. But when $n = 0$, it is $B = 0$. Therefore $a = 0$, and $B = -n$. Thirdly, $C = \underset{\prime}{C} + \underset{\prime}{B}$, that is, $\underset{.}{C} = \underset{\prime}{n}$. And returning to the Integrals 'tis $C = \frac{n\underset{\prime}{n}}{2} + b$. But when $n = 0$, 'tis $C = 0$; therefore $b = 0$, and $C = \frac{n\underset{\prime}{n}}{2}$, that is, $n \times \frac{n+1}{2}$. Fourthly, in the ſame Manner it will be found, that $D = -n \times \frac{n+1}{2} \times \frac{n+2}{3}$. And proceeding thus the other Coefficients will be found.

Scholium 1. In this Propoſition compared with the firſt Propoſition, it may be perceived that there is a certain ſingular Relation between Increments and their Integrals. For as in vulgar Arithmetick Multiplication and Diviſion are ſo contrary, that if Multiplication is denoted by an affirmative Index, Diviſion will be denoted by an Index with a contrary Sign; ſo in the Method of Increments, if an Increment be denoted by an affirmative Index, a negative Index will affect the Integral. Thus in the firſt Propoſition, if for n be taken the Number 2, by the Formula the ſecond Increment of xv will be exhibited, that is $\underset{\prime\prime}{x}v + 2\underset{\prime}{x}\underset{.}{v} + x\underset{..}{v}$.

But if for n the negative Number — 2 is taken, that now may be ſought the negatively ſecond Increment (if we may ſay ſo) of x o, which is the ſame Thing as the ſecond Integral, the Coefficients come out the ſame as if n were taken affirmatively in the preſent Propoſition; and as the Quantities x, $\underset{\prime}{x}$, $\underset{\prime\prime}{x}$, &c. moreover being interpreted by $[\overset{2}{x}]$, $[\underset{\prime}{\overset{3}{x}}]$, $[\underset{\prime\prime}{\overset{4}{x}}]$, &c. the Series becomes intirely the ſame as by the former Propoſition, where the ſecond Integral is required.

2. And from theſe Formulæ, as it were on their own Accord, proceed the Formulæ of the eleventh and twelfth Propoſitions of the Book concerning the Method of Increments. For if for the Increments are wrote the Fluxions, and the Increments vaniſhing all the x, $\underset{\prime}{x}$, $\underset{\prime\prime}{x}$, $\underset{\prime\prime\prime}{x}$, &c. become equal; then this ſecond Propoſition will immediately be changed into that eleventh, and the preſent third into that twelfth, which is a remarkable Example of the *Newtonian* Method, by which he collects the Ratio's of the Fluxions from the laſt Ratio's of the vaniſhing Increments, or the firſt Ratio's of the naſcent Increments.

A Poſtſcript by the ſame. ibid. p. 683.

Supplement. Being wholly engaged in the printing of the foregoing Treatiſe, and taking care to correct the Errors of the Preſs, and upon that Occaſion thinking often on theſe Matters; that Artifice came into my Mind, which Mr. *James Bernoulli* formerly made Uſe of, in the Invention of certain Series, by the Help of an harmonical Progreſſion, which Mr. *Monmort* mentions in *Schol.* 6. *Prop.* 5. aforegoing: That it may be conveniently apply'd to the finding Mr. *Monmort*'s Propoſitions 2, 3, 4, 5, and others of that Kind perhaps ſomething more general. To ſhew this in the few following Words, I thought would not be unacceptable to the Reader.

Theor. Let there be an Arithmetical Progreſſion p, $p+n$, $p+2n$, $p+3n$, &c. whoſe ſeveral Terms may ſucceſſively be denoted by x. And let b, c, d, &c. be any Multiples of the given Difference n of the Terms of that Progreſſion. Let A, B, C, D, &c. be any given Numbers, and let them conſtitute any Fractions $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, $\frac{D}{x+d}$, &c. For x writing ſucceſſively its Values p, $p+n$, $p+2n$, &c. and from any of theſe Fractions will ariſe a Series of harmonically Proportionals. Thus for Inſtance, from the firſt Fraction $\frac{A}{p}$ ariſes the Series $\frac{A}{p}$, $\frac{A}{p+n}$, $\frac{A}{p+2n}$, &c. I ſay that the Aggregate of any Number of ſuch Series continued *in infinitum* may be exhibited in a finite Number of Terms, if only the Aggregate of the Numerators A, B, C, D, &c. be equal to nothing. This will be evident from the two following Examples.

Ex. 1. Let there be only two Fractions $\frac{A}{x}$ and $\frac{-A}{x+3n}$, it being $b = 3n$. Let harmonical Series be wrote ariſing from theſe Forms, in ſuch an Order, that the Terms in which are the equal Denominators may anſwer one another, and the Sums of the homologous Terms being collected, the Aggregate of the ſeveral Series will ariſe in a finite Number of Terms, as may be ſeen in the Calculation following.

$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+\frac{A}{p+3n}+\frac{A}{p+4n}$, &c. = to the Series from $\frac{A}{x}$.

$+\frac{-A}{p+3n}+\frac{-A}{p+4n}$, &c. = to the Series from $\frac{-A}{x+3n}$.

$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+0+0$ &c. = Aggregate of the two Series.

Ex. 2. Let there be three Fractions $\frac{A}{x}$, $\frac{B}{x+2n}$, $\frac{C}{x+3n}$, and let $b = 2n$, $c = 3n$, and $A+B+C=0$. In this Caſe the Calculation is thus.

$\frac{A}{p}+\frac{A}{p+n}+\frac{A}{p+2n}+\frac{A}{p+3n}$, &c. = to the Series ariſing from $\frac{A}{x}$.

$+\frac{B}{p+2n}+\frac{B}{p+3n}$, &c. = to the Series from $\frac{B}{x+2n}$.

$+\frac{C}{p+3n}$, &c. = to the Series from $\frac{C}{x+3n}$.

$\frac{A}{p}+\frac{A}{p+n}+\frac{A+B}{p+2n}+\left(\frac{A+B+C}{p+3n}=0\right)$ = to the Aggregate of the three Series.

Here the Aggregate of the Series comes forth in a finite Number of Terms, that is $\frac{A}{p}+\frac{A}{p+n}+\frac{A+B}{p+2n}$, becauſe the Aggregate of the Numerators A, B, C, is equal to nothing. And in the ſame Manner may the Theorem be demonſtrated in all Caſes whatever.

Cor. 1. From theſe Principles may be derived an Infinity of infinite Series, which yet are ſummable in finite Terms.

Caſ. 1. Let $\frac{1}{x}$ and $\frac{-A}{x+b}$ be the Formulæ of two harmonical Series, the Aggregate of which comes out in a finite Number of Terms by what is demonſtrated above. Then thoſe Formulæ being collected, $\frac{Ab}{x \times \overline{x+b}}$ becomes the Formula of the ſummable Series. Make for Inſtance $A = \frac{1}{6}$, $p = 1$, $n = 2$, and $b = 3n = 6$. Then the Formulæ of the harmonical Series will be $\frac{1}{6x}$ and $\frac{1}{6 \times \overline{x+6}}$. The Formula of the compound ſummable Series will be $\frac{1}{x \times \overline{x+6}}$, that Series being $\frac{1}{1 \times 7} + \frac{1}{3 \times 9} + \frac{1}{5 \times 11} + \frac{1}{7 \times 13}$, &c. and the Sum of the Series, by the Calculus demonſtrated before will be $\frac{1}{6 \times 1} + \frac{1}{6 \times 3} + \frac{1}{6 \times 5}$. Let there be three Formulæ of harmonical Series, $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, it being $A + B + C = 0$, that the Aggregate of the three Series may be finite, by what goes before. Then the Formulæ being collected into one, will be

$$\frac{A \times \overline{x+b} \times \overline{x+c} + Bx \times \overline{x+c} + Cx \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c}},$$

or (the Terms being reduced to the Form of the Factors x, $x \times \overline{x+b}$, $x \times \overline{x+b} \times \overline{x+c}$)

$$\frac{Acb + \overline{Ac + \overline{c-b}\,B} \times x + \overline{A+B+C} \times x \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c}},$$

that is, (becauſe of $A + B + C = 0$) $\frac{Acb + \overline{Ac + B \times \overline{c-b}} \times x}{x \times \overline{x+b} \times \overline{x+c}}$, the Formula of the ſummable Series,

If there are four Fractions $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, $\frac{D}{x+d}$, if $A + B + C + D = 0$, the formula of the ſummable Series will be found in the ſame Manner to be

$$\frac{Abcd + \overline{Acd + B \times \overline{c-b} \times \overline{d-b}} \times x + \overline{Ad + B \times \overline{d-b} + C \times \overline{d-c}} \times x \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c} \times \overline{x+d}}.$$

And ſo we might go on to ſtill more compounded Formulæ.

Caſe 2, And if there are ſeveral Formulæ of ſuch ſummable Series, the Factors of whoſe Denominators are taken out of different Arithmetical Progreſſions, by the Addition of any Number of thoſe Formulæ into one, a new Formula will be compoſed of a ſummable Series. For Example Sake let there be two Formulæ of ſummable Series $\frac{1}{x\times\overline{x+3}}$ and $\frac{1}{z\times\overline{z+2}}$, x being taking out of the Arithmetical Progreſſion 1, 2, 3, 4, *&c.* and z out of the Progreſſion 1, 3, 5, 7, *&c.* then of theſe Formulæ collected into one Sum will be made a new Formula $\frac{z\times\overline{z+2}+x\times\overline{x+3}}{x\times\overline{x+3}\times z\times\overline{z+2}}$, or $\frac{\overline{2x-1}\times\overline{2x+1}+x\times\overline{x+3}}{x\times\overline{x+3}\times\overline{2x-1}\times\overline{2x+1}}$, when z is expounded by x and given Numbers.

Cor 2. Hence every infinite Series is ſummable, whoſe Terms are denoted by a Fraction, the Factors of whoſe Denominator are taken out of any Arithmetical Progreſſion; and the Numerator is a Multinomium whoſe Dimenſions are at leaſt fewer by two than the Dimenſions of the Denominator. For every Fraction of this Kind may be reſolved into ſo many ſimple Fractions, as are the Dimenſions (that is, the Number of Factors) of the Denominator, of which Numerators the Aggregate is nothing. For Example, let the propoſed Formula be $\frac{\alpha+\beta x+\gamma x\times\overline{x+b}}{x\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}}$. Suppoſe this Formula to be equal to the Aggregate of the Fractions $\frac{A}{x}+\frac{B}{x+b}+\frac{C}{x+c}+\frac{D}{x+d}$. Then thoſe Fractions being collected into one Sum, it will be $Abcd+\overline{Acd+B\times\overline{c-b}\times\overline{d-b}}\times x+\overline{Ad+B\times\overline{d-b}+C\times\overline{d-c}}\times x\times\overline{x+b}+\overline{A+B+C+D}\times x\times\overline{x+b}\times\overline{x+c}$, apply'd to $x\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}$, is equal to the Fraction $\frac{\alpha+\beta x+\gamma x\times\overline{x+b}}{x\times\overline{x+b}\times\overline{x+c}\times\overline{x+d}}$.

Then by comparing the homologous Terms, it is $Abcd=\alpha$, $Acd+B\times\overline{c-b}\times\overline{d-b}=\beta$, $Ad+B\times\overline{d-b}+C\times\overline{d-c}=\gamma$, $A+B+C+D=0$, and therefore $A=\frac{\alpha}{bcd}$, $B=\frac{\beta-Acd}{\overline{c-b}\times\overline{d-b}}$,

$C=$

$C = \frac{\gamma - Ad - B \times \overline{d-b}}{d-c}$, $D = -A-B-C$. By which Means the propoſed Formula is reſolved into the ſimple Fractions $\frac{\alpha}{bcdx} +$ $\frac{\beta - Acd}{\overline{c-b} \times \overline{d-b} \times \overline{x+b}} + \frac{\gamma - Ad - B \times \overline{d-b}}{\overline{d-c} \times \overline{x+c}} + \frac{-A-B-C}{x+d}$. by which the Aggregate of the ariſing Series, that is, the Sum of the Series ariſing from the propoſed Formula $\frac{\alpha + \beta x + \gamma x \times \overline{x+b}}{x \times \overline{x+b} \times \overline{x+c} \times \overline{x+d}}$, comes forth in finite Terms, by what has been ſaid. Now that the Dimenſions of the Numerator in the propoſed Formula muſt be fewer by two at leaſt than the Dimenſions of the Denominator, will appear from hence, that in the Reduction of the Fractions $\frac{A}{x}$, $\frac{B}{x+b}$, $\frac{C}{x+c}$, $\frac{D}{x+d}$, every Numerator A, B, C, D, is multiply'd into all the Denominators except one, which is its own. Whence the Dimenſions of the Numerator come forth one leſs than the Dimenſions of the Denominator. But by the Equation $A+B+C+D=0$ the higheſt Dimenſion in the Numerator is loſt; whence there remain the Dimenſions of the Numerator fewer at leaſt by two than the Dimenſions of the Denominator. Now to this Corollary may be reduced Mr. de *Monmort*'s Propoſitions 2d and 5th.

Cor. 3. Alſo a Formula being propoſed according to *Caſ.* 2. *Cor.* 1. ſtill more compounded, it may be perceived from the ſame Principles whether the Series be ſummable. Let there be two Arithmetical Progreſſions 1, 3, 5, &c. 2, 4, 6, &c. the homologous Terms of which may be denoted by x and z, and let the propoſed Formula of the Series be $\frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+2} \times z \times \overline{z+2}}$, or (for z writing $x+1$, and the Factors of the Denominator being reduced into Order,) $\frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}$. Suppoſe this Formula to be equal to the Aggregate of the Formulæ $\frac{P}{x \times \overline{x+2}}$, $\frac{Q}{\overline{x+1} \times \overline{x+2}}$, of Series that are ſummable by what is ſaid above, that (when theſe laſt Formulæ are collected into one Sum) it may be

$$\frac{P \times \overline{x+1} \times \overline{x+3} + Q \times x \times \overline{x+2}}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}, \text{ or}$$

$$\frac{3P + \overline{4P+2Q} \times x + \overline{P+Q} \times x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}} = \frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}$$

Hence comparing the homologous Terms, theſe Equations ariſe, $3P = \alpha$, $4P + 2Q = \beta$, $P + Q = \gamma$. Whence P and Q being eliminated by juſt Analytical Reductions, there will ariſe the Equation $2\alpha - 3\beta + \gamma = 0$, by which the Relation will be determined, which muſt obtain among the Coefficients α, β, γ, in order that the Series may be ſummable, which ariſes from the propoſed Formula

$$\frac{\alpha + \beta x + \gamma x^2}{x \times \overline{x+1} \times \overline{x+2} \times \overline{x+3}}.$$

In the ſame Manner if the Factors of the propoſed Formula of the Denominator are taken out of three Arithmetical Progreſſions, two Equations will be found, by which the Relations of the Coefficients of the Numerator will be determined, in order that the Series may be ſummable. If there are four Arithmetical Progreſſions, the Relation of the Coefficients will be determin'd by three Equations. And ſo on. And in ſuch Formulæ, in order that the Series may be ſummable, it is farther to be obſerved; firſt, that the Dimenſions of the Numerators may at leaſt be leſs by two than the Dimenſions of the Denominators; likewiſe that out of each of the Arithmetical Progreſſions be taken at leaſt two Factors of the Denominator. Laſtly, if two or more Factors of the Denominator are equal to each other, it muſt be ſuppoſed that ſo many Arithmetical Progreſſions, out of which they are taken, are alſo equal. The Premiſes being duly conſider'd, theſe Things will be evident. Now to this Corollary are eaſily reduced the third and fourth Propoſitions of Mr. de *Monmort.*

XIX. *Propoſition.* To find a Parabolical Line, which ſhall paſs through the Extremities of any Number of equidiſtant Ordinates.

The Newtonian Differential Method explain'd, by Mr. J. Stirling, n. 362. p. 1050. Fig. 33.

$$\begin{array}{ccccccccccccccccc}
A & & A2 & & A3 & & A4 & & A5 & & A6 & & A7 & & A8 & & A9\\
& B & & B2 & & B3 & & B4 & & B5 & & B6 & & B7 & & B8 & \\
& & C & & C2 & & C3 & & C4 & & C5 & & C6 & & C7 & & \\
& & & D & & D2 & & D3 & & D4 & & D5 & & D6 & & & \\
& & & & E & & E2 & & E3 & & E4 & & E5 & & & & \\
& & & & & F & & F2 & & F3 & & F4 & & & & & \\
& & & & & & G & & G2 & & G3 & & & & & & \\
& & & & & & & H & & H2 & & & & & & & \\
& & & & & & & & I & & & & & & & &
\end{array}$$

Caſ. 1. Let A, $A2$, $A3$, $A4$, *&c.* denote equidiſtant Ordinates inſiſting upon an Abſciſs in a given Angle. Collect their Differences B, $B2$, $B3$, $B4$, *&c* and the Differences of theſe C, $C2$, $C3$, *&c.* and the Differences of theſe D, $D2$, $D3$, *&c.* and of theſe E, $E2$, $E3$, *&c.* and of theſe F, $F2$, $F3$, *&c.* And ſo on. Now the Differences muſt be collected by always taking the former from the latter. That is, making $B = A2 - A$, $B2 = A3 - A2$, $B3 = A4 - A3$, $B4 = A5 - A4$, *&c.* Then $C = B2 - B$, $C2 = B3 - B2$, $C3 = B4 - B3$, *&c.* Then $D = C2 - C$, $D2 = C3 - C2$, $D3 = C4 - C3$, *&c.* And all the following Differences muſt be collected in the ſame Manner. Or let α, β, γ, δ, ϵ, ζ, η, *&c.* be equal to A, $A2$, $A3$, $A4$, $A5$, $A6$, $A7$, *&c.* reſpectively; then $A = \alpha$, $B = \beta - \alpha$, $C = \gamma - 2\beta + \alpha$, $D = \delta - 3\gamma + 3\beta - \alpha$, $E = \epsilon - 4\delta + 6\gamma - 4\beta + \alpha$, $F = \zeta - 5\epsilon + 10\delta - 10\gamma + 5\beta - \alpha$, $G = \eta - 6\zeta + 15\epsilon - 20\delta + 15\gamma - 6\beta + \alpha$, *&c.* In theſe Values the numeral Coefficients of α, β, γ, δ, ϵ, *&c.* are generated as in the integer Powers of the Binomial $\overline{1-z}|^{0}$, $\overline{1-z}|^{1}$, $\overline{1-z}|^{2}$, $\overline{1-z}|^{3}$, $\overline{1-z}|^{4}$, *&c.* by writing the Numbers 1, 2, 3, 4, 5, *&c.* in the Series $1 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4}$, *&c.* inſtead of n ſucceſſively. Now let PQ be any Ordinate intermediate to the reſt, and let AP its Diſtance from the firſt Ordinate A be called z, then it will be

$$PQ = A +$$

$$B \times \frac{z}{1} +$$

$$C \times \frac{z}{1} \times \frac{z-1}{2} +$$

$D \times$

$$D \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} +$$

$$E \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} +$$

$$F \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} \times \frac{z-4}{5} +$$

$$G \times \frac{z}{1} \times \frac{z-1}{2} \times \frac{z-2}{3} \times \frac{z-3}{4} \times \frac{z-4}{5} \times \frac{z-5}{6} + \text{\&c.}$$

Here the Sign of z is to be changed, whenever PQ falls on the other Side of the firſt Ordinate, as pq.

Caſ. 2. Now let $A\,5$ be an Ordinate in the Middle of all; make $A = B\,4 + B\,5$, $B = D\,3 + D\,4$, $C = F\,2 + F\,3$, $D = H + H\,2$, &c. and $a = C\,4$, $b = E\,3$, $c = G\,z$, $d = I$, &c. that is, if it be $A\,6 = \alpha$, $A\,7 = \beta$, $A\,8 = \gamma$, $A\,9 = \delta$, &c. $A\,4 = \kappa$, $A\,3 = \lambda$, $A\,2 = \mu$, $A = \nu$, &c. Make $A = \alpha - \kappa$, $B = \beta - 2\alpha + 2\kappa - \lambda$, $C = \gamma - 4\beta + 5\alpha - 5\kappa + 4\lambda - \mu$, $D = \delta - 6\gamma + 14\beta - 14\alpha + 14\kappa - 14\lambda + 6\mu - \nu$, &c. $a = \alpha - 2A\,5 + \kappa$, $b = \beta - 4\alpha + 6A\,5 - 4\kappa + \lambda$, $c = \gamma - 6\beta + 15\alpha - 20A\,5 + 15\kappa - 6\lambda + \mu$, $d = \delta - 8\gamma + 28\beta + 56\alpha + 70A\,5 - 56\kappa + 28\lambda - 8\mu + \nu$, &c. And let $A\,5\,P$ be called z. Then it will be

$$PQ = A\,5 + \frac{Az + azz}{1 \cdot 2} +$$

$$\frac{2Bz + bzz}{1 \cdot 2} \times \frac{zz-1}{3 \cdot 4} +$$

$$\frac{3Cz + czz}{1 \cdot 2} \times \frac{zz-1}{3 \cdot 4} \times \frac{zz-4}{5 \cdot 6} +$$

$$\frac{4Dz + dzz}{1 \cdot 2} \times \frac{zz-1}{3 \cdot 4} \times \frac{zz-4}{5 \cdot 6} \times \frac{zz-9}{7 \cdot 8} +$$

$$\frac{5Ez + ezz}{1 \cdot 2} \times \frac{zz-1}{3 \cdot 4} \times \frac{zz-4}{5 \cdot 6} \times \frac{zz-9}{7 \cdot 8} \times \frac{zz-16}{9 \cdot 10} + \text{\&c.}$$

Caſ. 3. Now let $A4$, $A5$, be two Ordinates in the Middle of all, Make $A = \frac{A4 + A5}{2}$, $B = \frac{C3 + C4}{2}$, $C = \frac{E2 + E3}{2}$, $D = \frac{G + G2}{2}$, &c. $a = B4$, $b = D3$, $c = F2$, $d = H$, &c. Or let $A5 = \alpha$, $A6 = \beta$, $A7 = \gamma$, $A8 = \delta$, $A4 = \kappa$, $A3 = \lambda$, $A2 = \mu$, $A = \nu$, &c. Then it will be $2A = \alpha + \kappa$, $2B = \beta - \alpha - \kappa + \lambda$, $2C = \gamma - 3\beta + 2\alpha + 2\kappa - 3\lambda + \mu$, $2D = \delta - 5\gamma + 9\beta - 5\alpha - 4\kappa + 9\lambda - 5\mu + \nu$, &c. And $a = \alpha - \kappa$, $b = \beta - 3\alpha + 3\kappa - \lambda$, $c = \gamma - 5\beta + 10\alpha - 10\kappa + 5\lambda - \mu$, $d = \delta - 7\gamma + 21\beta - 35\alpha + 35\kappa - 21\lambda + 7\mu - \nu$, &c. And let O be the middle Point between $A4$, $A5$, and let OP be called z. Then the Ordinate will be

$$PQ = \frac{A + az}{4^0} +$$

$$\frac{3B + bz}{4^1} \times \frac{4zz - 1}{2 \cdot 3} +$$

$$\frac{5C + cz}{4^2} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} +$$

$$\frac{7D + dz}{4^3} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} +$$

$$\frac{9E + ez}{4^4} \times \frac{4zz - 1}{2 \cdot 3} \times \frac{4zz - 9}{4 \cdot 5} \times \frac{4zz - 25}{6 \cdot 7} \times \frac{4zz - 49}{8 \cdot 9} + \text{\&c.}$$

Alſo in theſe two Caſes z is negative, when the Ordinate PQ falls on the other Side of the Beginning of the Abſciſs. And in all the three Caſes the Common Diſtance of the Ordinates is ſuppoſed Unity.

All the three Caſes are very eaſily demonſtrated by Calculation. In the firſt Caſe for PQ I write ſucceſſively α, β, γ, δ, &c. and for z at the ſame Time 0, 1, 2, 3, 4, &c. which are the Lengths of the Abſciſs following in Order. Thence ariſe theſe Equations,

$\alpha = A$, $\beta = A + B$, $\gamma = A + 2B + C$, $\delta = A + 3B + 3C + D$, $\varepsilon = A + 4B + 6C + 4D + E$, &c.

$\beta - \alpha = B$, $\gamma - \beta = B + C$, $\delta - \gamma = A + 2C + D$, $\varepsilon - \delta = B + 3C + 3D + E$, &c.

$\gamma - 2\beta + \alpha = C$, $\delta - 2\gamma + \beta = C + D$, $\varepsilon - 2\delta + \gamma = C + 2D + E$, &c.

$\delta - 3\gamma + 3\beta - \alpha = D$, $\varepsilon - 3\delta + 3\gamma - \beta = D + E$, *&c.*
$\varepsilon - 4\delta + 6\gamma - 4\beta + \alpha = E$, *&c.*

Theſe Equations are eaſily reſolved, by taking their Differences, as may here be ſeen. And they give us the ſame Values of A, B, C, D, *&c.* as are before ſuppoſed in the Solution. The other two Caſes are demonſtrated after the ſame Manner.

Every one of theſe three Series will converge to the Value of the Ordinate PQ, when the Differences of the given Ordinates are of a proper Magnitude. But when they do not converge, other Expedients are to be try'd. At preſent we ſhall add a few Things about the Uſe of this Propoſition.

Let α, β, γ, δ, ε, ζ, η, θ, *&c.* repreſent any equidiſtant Terms, whoſe Differences are very ſmall; and let the Relations which they have to one another be nearly repreſented by the following Equations, which ariſe by taking the Differences, and the Differences of the Differences continually, and making them equal to nothing.

$$\alpha - \beta = 0$$
$$\alpha - 2\beta + \gamma = 0$$
$$\alpha - 3\beta + 3\gamma - \delta = 0$$
$$\alpha - 4\beta + 6\gamma + 4\delta + \varepsilon = 0$$
$$\alpha - 5\beta + 10\gamma - 10\delta + 5\varepsilon - \zeta = 0$$
$$\alpha - 6\beta + 15\gamma - 20\delta + 15\varepsilon - 6\zeta + \eta = 0$$
$$\alpha - 7\beta + 21\gamma - 35\delta + 35\varepsilon - 21\zeta + 7\eta - \theta = 0$$
$$\alpha - 8\beta + 28\gamma - 56\delta + 70\varepsilon - 56\zeta + 28\eta - 8\theta + \kappa = 0$$
$$\alpha - 9\beta + 36\gamma - 84\delta + 126\varepsilon - 126\zeta + 84\eta - 36\theta + 9\kappa - \lambda = 0$$
&c.

This Table muſt be kept for Uſe, to be conſulted when Occaſion requires. Now that theſe Equations either obtain accurately, or approximate to the Truth when the Differences of the Terms are ſmall, may appear from the Demonſtration of the Propoſition of the firſt Caſe.

Let any Series be aſſumed, $\frac{1}{101}$, $\frac{1}{102}$, $\frac{1}{103}$, $\frac{1}{104}$, $\frac{1}{105}$, $\frac{1}{106}$, *&c.* and let the Term be ſought which ſtands the next before $\frac{1}{101}$. It is plain this is $\frac{1}{100}$; let us ſee then what this Method will make it. Let α denote the Term required, then it will be

	Equation.		
$\frac{1}{101} = \beta =$ 0099,0099,0099,0,	1	gives α	0099,0099,0099,0
$\frac{1}{102} = \gamma =$ 0098,0392,1568,7,	2		0099,9805,8629,3
$\frac{1}{103} = \delta =$ 0097,0873,7864,1,	3		0099,9994,3455,0
$\frac{1}{104} = \varepsilon =$ 0096,1538,4615,4,	4		0099,9999,7824,8
$\frac{1}{105} = \zeta =$ 0095,2380,9523,8,	5		0099,9999,9895,8
$\frac{1}{106} = \eta =$ 0094,3396,2264,2,	6		0099,9999,9993,1

Therefore it is evident, that this Method continually approximates. If the Differences of the Terms had been leſs, the Values would have approached faſter to the Truth, and on the other Hand ſlower, if thoſe Differences ſhould be greater. Hence if a Term ſhould be wanting in Numeral Tables, it may be interpolated by this Method.

Alſo by this Method come forth the very ſame Algebraical Series themſelves, that are uſed to ariſe by other Methods. Let $\overline{1+zz}|^{-1}$ be propoſed as the Ordinate of a Curve which is to be ſquared. It is the firſt in the regular Series $\overline{1+zz}|^{-1}$, $\overline{1+zz}|^{0}$, $\overline{1+zz}|^{1}$, $\overline{1+zz}|^{2}$, $\overline{1+zz}|^{3}$, &c. of Ordinates, all which except the firſt give their Areas z, $z+\frac{1}{3}z^3$, $z+\frac{2}{3}z^3+\frac{1}{5}z^5$, $z+\frac{3}{3}z^3+\frac{3}{5}z^5+\frac{1}{7}z^7$, &c. conſtituting a new Series, of which the firſt Term will be the Area required. This therefore will be found by putting α to repreſent it; and β, γ, δ, ε, &c. for the reſt in their Order. The firſt Equation gives $\alpha = z$: The ſecond $\alpha = z - \frac{1}{3}z^3$: The third $\alpha = z - \frac{1}{3}z^3 + \frac{1}{5}z^5$: The fourth $\alpha = z - \frac{1}{3}z^3 + \frac{1}{5}z^5 - \frac{1}{7}z^7$: And ſo for the reſt. Therefore the Area required is univerſally $z - \frac{1}{3}z^3 + \frac{1}{5}z^5 - \frac{1}{7}z^7 + \frac{1}{9}z^9 - \frac{1}{11}z^{11}$, &c. Which Series is the Arch whoſe Tangent is z, in a Circle the Radius of which is Unity. This was found by our Mr. *James Gregory*, and communicated to Mr. *Collins* the Beginning of the Year 1671, from whom, by Means of Mr. *Oldenburg*, it came to the Hands of Mr. *Leibnitz*.

Now let &c. e, d, c, b, a, P, α, β, γ, δ, ε, &c. be a Series proceeding both Ways *in infinitum*, where all the Terms are given except P in the Middle of all. Make $A = \alpha + a$, $B = \beta + b$, $C = \gamma + c$, $D = \delta + d$, $E = \varepsilon + e$, &c. and it will be

$$P = \frac{A}{2} +$$

$$\frac{A - B}{6} +$$

$$\frac{5A - 8B + 3C}{60} +$$

$$\frac{7A - 14B + 9C - 2D}{140} +$$

$$\frac{42A - 96B + 81C - 32D + 5E}{1260} +$$

$$\frac{66A - 165B + 165C - 88D + 25E - 3F}{2772} +$$

$$\frac{429A - 1144B + 1287C - 832D + 325E - 72F + 7G}{24024} + \&c.$$

This Series is found by the Equations, by taking thoſe alternately in which the Number of the Terms is odd. For their Differences will leave the Terms in this Series, which therefore may be produced at Pleaſure.

Let $\overline{1+z}|^{-1}$ be the Ordinate of an Hyperbola, and let its Area be ſought, which lies above the Abſciſs z, when that becomes Unity. This Ordinate is the Middlemoſt in the Series of Ordinates, &c. $\overline{1+z}|^{-5}$, $\overline{1+z}|^{-4}$, $\overline{1+z}|^{-3}$, $\overline{1+z}|^{-2}$, $\overline{1+z}|^{-1}$, $\overline{1+z}|^{0}$, $\overline{1+z}|^{1}$, $\overline{1+z}|^{2}$, $\overline{1+z}|^{3}$, &c. which are equidiſtant, and proceed both Ways *in infinitum*. Therefore the Areas generated by theſe Ordinates will conſtitute a like Series, whoſe middle Term will be the Area required; which therefore may be obtained by the foregoing Series. When z is Unity, as in the preſent Caſe, the Areas of the Curves become &c. $\frac{15}{64}$, $\frac{7}{24}$, $\frac{3}{8}$, $\frac{1}{2}$, and 1, $\frac{3}{2}$, $\frac{7}{3}$, $\frac{15}{4}$, &c. Hence $A = 1 + \frac{1}{2}$, $B = \frac{3}{2} + \frac{3}{8} = \frac{15}{8}$, $C = \frac{7}{3} + \frac{7}{24} = \frac{21}{8}$, $D = \frac{15}{4} + \frac{15}{64} = \frac{255}{64}$, &c. Theſe being ſubſtituted in the Series, P or the Area of the Hyperbola comes out $\frac{3}{4} - \frac{3}{48} + \frac{3}{480} - \frac{4}{4480}$, &c.

that is, $\frac{3}{4} - \frac{A}{4\cdot 3} - \frac{2B}{4\cdot 5} - \frac{3C}{4\cdot 7} - \frac{4D}{4\cdot 9} - \frac{5E}{4\cdot 11}$, &c. where now A, B, C, D, &c. (after *Newton's* Manner) denote the Terms in Order from the Beginning. I add the Calculation.

TERMS.

TERMS.

Affirmative.	*Negative.*
7500,0000,0000,0000,0	0625,0000,0000,0000,0
62,5000,0000,0000,0	6,6964,2857,1428,5
7440,4761,9047,6	845,5086,5800,8
97,5586,9130,8	11,3818,4731,9
1,3390,4086,1	1585,7062,8
188,7745,5	22,5708,7
2,7085,0	3260,2
393,4	47,5
5,7	7
+ 7563,2539,3900,7494,1	— 0631,7821,3370,8041,1

Subtracting the negative Sum from the affirmative, I have for the Area, that is, for the Hyperbolic Logarithm of 2, the Number 6931,4718,0559,9453.

The Series that follows is very convenient for the Construction of any Numeral Tables. Let &c. e, d, c, b, a, α, β, γ, δ, ε, &c. denote the alternate Terms in a Series proceeding both Ways *in infinitum*; put $A = \alpha + a$, $B = \beta + b$, $C = \gamma + c$, $D = \delta + d$, $E = \varepsilon + e$, &c. and the Term between α and a will be

$$\frac{A}{2} +$$

$$\frac{1}{1} \times \frac{A - B}{2^4} +$$

$$\frac{1 \cdot 3}{1 \cdot 2} \times \frac{2A - 3B + C}{2^7} +$$

$$\frac{1 \cdot 3 \cdot 5}{1 \cdot 2 \cdot 3} \times \frac{5A - 9B + 5C - D}{2^{10}} +$$

$$\frac{1 \cdot 3 \cdot 5 \cdot 7}{1 \cdot 2 \cdot 3 \cdot 4} \times \frac{14A - 28B + 20C - 7D + E}{2^{13}} +$$

$$\frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \times \frac{42A - 90B + 75C - 35D + 9E - F}{2^{16}} +$$

$$\frac{1\cdot3\cdot5\cdot7\cdot9\cdot11}{1\cdot2\cdot3\cdot4\cdot5\cdot6}\times\frac{132A-297B+275C-154D+54E-11F+G}{2^{19}}+$$

&c.

This Series follows from the third Caſe of the Propoſition, by making $z=0$. The numeral Coefficients of the Letters are thus produced; for Example, in the fourth Term the Coefficient of the laſt Letter but one C is 5; make $5+1=n$, and the Numbers which ariſe from the Multiplication of the Terms $1\times\frac{n}{1}\times\frac{n-1}{2}\times\frac{n-2}{3}\times\frac{n-3}{4}\times\frac{n-4}{5}$, *&c.* will be 1, 6, 15, 20, *&c.* The Differences of theſe 5, 9, 5, *&c*, are the Numbers required; and therefore the Series may be produced at Pleaſure.

Having given the Logarithms of the Numbers 46, 48, 50, 52, 54, 56, 58, 60, to find the Logarithm of the Number 53, which is in the Middle of all. Make $l.\ 52+l.\ 54=A=3,4483,7910,34$: $l.\ 50+l.\ 56=B=3,4471,5803,13$: $l.\ 48+l.\ 58=C=3,4446,6923,08$: $l.\ 46+l.\ 60=D=3,4409,0908,19$. Theſe Values being wrote in the Series, the firſt four Terms will give 1,7242,2586,96 for the Logarithm of the Number 53. And in the ſame Manner any other intermediate Number may be found.

Therefore in the Conſtruction of Tables it is ſufficient, firſt to find ſome Terms at due Diſtances, for the reſt may be inſerted in this Manner. For the Terms at firſt found are to be continually intercalated, till we arrive at laſt at thoſe that are deſired. By this Means the whole Table will be had, from a few given Terms at firſt as a Foundation for the Work. But it is not convenient that the Terms we firſt ſeek are all equidiſtant thro' the whole Table; for if we omit them by Turns, where their Difference is the greateſt, we may elſewhere *per ſaltum* omit two, three, twenty, or perhaps more Terms. But the Number of Terms that are omitted, conſiſting between two given ones, ought always to be one of the following, 1, 3, 7, 15, 31, 63, &c. if we would inſert them by this Series; for this by no Means would be any Hindrance to the Work.

But for Practice the Terms may be collected into one Sum, as you ſee done in this Table. The firſt Expreſſion is the firſt Term; the ſecond is the Sum of the firſt and ſecond; the third is the Sum of the firſt, ſecond, and third; and ſo on.

2	$\frac{A}{2}$
4	$\frac{9A - B}{16}$
6	$\frac{150A - 25B + 3C}{256}$
8	$\frac{1225A - 245B + 49C - 5D}{2048}$
10	$\frac{39690A - 8820B + 2268C - 305D + 35E}{65536}$

Thus ſome of the alternate Terms being given, the intermediate ones will be preſently found by theſe Expreſſions, without taking any Notice of the particular Nature of the Table. For theſe Rules are the ſame in all. The Areas of Curves are nearly equal to the Areas of the Parabolical Figure which paſſes through the Extremities of its Ordinates. But becauſe it would be too laborious always to have Recourſe to the Parabola, I have computed the following Table, by which the Areas are exhibited directly from the Ordinates being given.

1	$\frac{A}{1}R$
3	$\frac{A + 4B}{6}R$
5	$\frac{7A + 32B + 12C}{90}R$
7	$\frac{41A + 216B + 27C + 272D}{840}R$
9	$\frac{989A + 5888B - 928C + 10496D - 4540E}{28350}R$
11	$\frac{16067A + 106300B - 48525C + 272400D - 260550E + 427368F}{598752}R$

Here the Number of the Ordinates is odd, *A* is the Sum of the firſt and laſt, *B* of the ſecond and laſt but one, *C* of the third and laſt but two; and ſo on, till you come to that which is in the Middle of all, which is repreſented by the laſt Letter in every Expreſſion. *R* is the Baſe, or that Part of the Abſciſs which is intercepted between the firſt and the laſt Ordinate. The Expreſſions are the Areas contained between the Curve, the Baſe, and the extream Ordinates on both Sides. I have not added the Table for Ordinates that are even in Number, becauſe when every Thing elſe is alike, the Area is defined more accurately ~~from~~ an odd Number of Ordinates.

Let the Area be required which is generated by the Ordinate $\overline{1+zz}|^{-1}$, and lies upon the Abſciſs z when it becomes Unity. In $\overline{1+zz}|^{-1}$ for z write $\frac{0}{10}$, $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$, $\frac{4}{10}$, $\frac{5}{10}$, $\frac{6}{10}$, $\frac{7}{10}$, $\frac{8}{10}$, $\frac{9}{10}$, $\frac{10}{10}$; and eleven Ordinates will ariſe 1, $\frac{100}{101}$, $\frac{25}{26}$, $\frac{100}{109}$, $\frac{25}{29}$, $\frac{4}{5}$, $\frac{25}{34}$, $\frac{100}{149}$, $\frac{25}{41}$, $\frac{100}{181}$, $\frac{1}{2}$. Hence $A = 1 + \frac{1}{2} = \frac{3}{2}$, $B = \frac{100}{101} + \frac{100}{181} = \frac{28200}{18281}$, $C = \frac{25}{26} + \frac{25}{41} = \frac{1675}{1066}$, $D = \frac{100}{109} + \frac{100}{149} = \frac{25800}{16241}$, $E = \frac{25}{29} + \frac{25}{34} = \frac{1575}{986}$, $F = \frac{4}{5}$. Theſe Values being ſubſtituted in the laſt Expreſſion, and Unity for *R*, you will find the Area to be 785398187; which Number is true in the ſeventh Figure, but in the eighth it is too much by 2.

If eleven Ordinates do not give the Area to ſufficient Exactneſs, you muſt erect more; and conceive the Area to be divided into more Parts; then ſeeking every one ſeparately, you may have the Whole to what Degree of Truth you pleaſe.

The Value of $\overline{1+Q}|^{n}$ may be expreſs'd by any one of the three following Series,

$$\overline{1+Q}|^{n} = 1 + Q \times \frac{n}{1} + Q^2 \times \frac{n}{1} \times \frac{n-1}{2} + Q^3 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} + Q^4 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} + Q^5 \times \frac{n}{1} \times \frac{n-1}{2} \times \frac{n-2}{3} \times \frac{n-3}{4} \times \frac{n-4}{5} + \&c.$$

Or $\overline{1+Q}^n = 1 +$

$$R\times\frac{n}{1}+$$

$$R^2\times\frac{n}{1}\times\frac{n+1}{2}+$$

$$R^3\times\frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}+$$

$$R^4\times\frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}\times\frac{n+3}{4}+$$

$$R^5\times\frac{n}{1}\times\frac{n+1}{2}\times\frac{n+2}{3}\times\frac{n+3}{4}\times\frac{n+4}{5}+\text{\&c.}$$

Here you muſt make $\frac{1+Q}{Q}=R.$

Or $\overline{1+Q}^n = 1 +$

$$\frac{2+\overline{n+1}\times Q}{\overline{1+Q}^1}\times Q\times\frac{n}{1\cdot 2}+$$

$$\frac{4+\overline{n+2}\times Q}{\overline{1+Q}^2}\times Q^3\times\frac{n}{1\cdot 2}\times\frac{nn-1}{3\cdot 4}+$$

$$\frac{6+\overline{n+3}\times Q}{\overline{1+Q}^3}\times Q^5\times\frac{n}{1\cdot 2}\times\frac{nn-1}{3\cdot 4}\times\frac{nn-4}{5\cdot 6}+$$

$$\frac{8+\overline{n+4}\times Q}{\overline{1+Q}^4}\times Q^7\times\frac{n}{1\cdot 2}\times\frac{nn-1}{3\cdot 4}\times\frac{nn-4}{5\cdot 6}\times\frac{nn-9}{7\cdot 8}+$$

$$\frac{10+\overline{n+5}\times Q}{\overline{1+Q}^5}\times Q^9\times\frac{n}{1\cdot 2}\times\frac{nn-1}{3\cdot 4}\times\frac{nn-4}{5\cdot 6}\times\frac{nn-9}{7\cdot 8}\times\frac{nn-16}{9\cdot 10}$$

$+$ &c.

The two firſt Series are demonſtrated by *Caſ.* 1. of the Propoſition. For if $\overline{1+\mathfrak{Q}}|^{0}$, $\overline{1+\mathfrak{Q}}|^{1}$, $\overline{1+\mathfrak{Q}}|^{2}$, $\overline{1+\mathfrak{Q}}|^{3}$, $\overline{1+\mathfrak{Q}}|^{4}$, *&c.* denote ſo many equidiſtant Ordinates in the Parabolical Figure, then will $\overline{1+\mathfrak{Q}}|^{n}$ be an Ordinate of the ſame, whoſe Diſtance from $\overline{1+\mathfrak{Q}}|^{0}$ will be n. And ſo comes forth the firſt Series. But if in another Parabola the equidiſtant Ordinates are $\overline{1+\mathfrak{Q}}|^{0}$, $\overline{1+\mathfrak{Q}}|^{-1}$, $\overline{1+\mathfrak{Q}}|^{-2}$, $\overline{1+\mathfrak{Q}}|^{-3}$, $\overline{1+\mathfrak{Q}}|^{-4}$, *&c.* then will $\overline{1+\mathfrak{Q}}|^{n}$ be an Ordinate in the ſame, the Diſtance of which from $\overline{1+\mathfrak{Q}}|^{0}$ will be $-n$. So will the ſecond Series come forth. Now in a third Parabola let *&c.* $\overline{1+\mathfrak{Q}}|^{-4}$, $\overline{1+\mathfrak{Q}}|^{-3}$, $\overline{1+\mathfrak{Q}}|^{-2}$, $\overline{1+\mathfrak{Q}}|^{-1}$, $\overline{1+\mathfrak{Q}}|^{0}$, $\overline{1+\mathfrak{Q}}|^{1}$, $\overline{1+\mathfrak{Q}}|^{2}$, $\overline{1+\mathfrak{Q}}|^{3}$, $\overline{1+\mathfrak{Q}}|^{4}$, *&c.* be a Series of equidiſtant Ordinates proceeding both Ways *in infinitum*, and in the ſame the Ordinate $\overline{1+\mathfrak{Q}}|^{n}$ will be removed from the middle Term $\overline{1+\mathfrak{Q}}|^{0}$ at the Diſtance n. And thus the third Series will come forth by the Second Caſe of the Propoſition. The firſt breaks off when n is an integer affirmative Number; the ſecond when n is integer and negative; and the third breaks off in either Caſe. The third converges much faſter than either of the other; its ſecond Term may be uſed as a Correction, when an Extraction is to be perform'd by the Repetition of the Calculus. By any of theſe the Roots of Numbers may conveniently be reduced to Series.

Dr. *Halley* in his Method of conſtructing the Logarithms, from the firſt of theſe Series demonſtrates *Mercator*'s Series for the Quadrature of the Hyperbola. Let its Ordinate be $\overline{1+z}|^{-1}$ or $\overline{1+z}|^{n-1}$, n being here an infinitely ſmall Number. Whence by the Method for Quadratures, the Area which lies above the Abſciſs z, that is, the Logarithm of the Number $1+z$, will be $\frac{\overline{1+z}|^{n}-1}{n}$. But by the firſt Series 'tis $\overline{1+z}|^{n}$ $= 1+\frac{n}{1}z+\frac{n}{1}\times\frac{n-1}{2}z^{2}+\frac{n}{1}\times\frac{n-1}{2}\times\frac{n-2}{3}z^{3}$, *&c.* And therefore in the preſent Caſe, in which n is infinitely ſmall, it will be $\overline{1+z}|^{n}=1+\frac{n}{1}z-\frac{n}{2}z^{2}+\frac{n}{3}z^{3}-\frac{n}{4}z^{4}+\frac{n}{5}z^{5}$, *&c.* which being ſubſtituted in the Value of the Area, it becomes $z-\frac{1}{2}z^{2}+\frac{1}{3}z^{3}-\frac{1}{4}z^{4}+\frac{1}{5}z^{5}$, *&c.* which is *Mercator*'s Series.

In like Manner by the ſecond Series this Rule comes forth. Let the given Number $1+z$; make $R=\frac{z}{1+z}$, and its Logarithm will be $R+\frac{1}{2}R^{2}+\frac{1}{3}R^{3}+\frac{1}{4}R^{4}+\frac{1}{5}R^{5}$, *&c.*

By the third Series comes out this Rule. Let R be any Number; make $z = \frac{\overline{R-1}^2}{2R}$, and its Logarithm will be $\frac{RR-1}{2R} - \frac{1}{3}Az - \frac{2}{5}Bz - \frac{3}{7}Cz - \frac{4}{9}Dz - \frac{5}{11}Ez$, &c. where A, B, C, D, &c. after *Newton*'s Method, denote the Terms of the Series in Order. This Series, as well as that from whence it is deduced, approximates much faſter than the other two, and is expreſs'd much more generally than that which we gave before, from a Foundation not unlike this, for finding the Logarithm of the Number 2.

A Method for finding the Values of Arithmetical Series, that converge never ſo ſlowly.

In ſome Series the Sum of the Terms cannot be had, except to a very few Places of Figures; till ſome other Artifice is made Uſe of, more than their meer Addition. Now let any Series be propoſed, all whoſe Terms are affected with the ſame Signs, and whoſe neareſt Terms continually tend to Equality. Such are the following $\frac{1}{1\cdot 2} + \frac{1}{3\cdot 4} + \frac{1}{5\cdot 6} + \frac{1}{7\cdot 8}$, &c. $1 + \frac{1}{4} + \frac{1}{9} + \frac{1}{16} + \frac{1}{25}$, &c. Collect the Sum of ſome of the Terms from the Beginning, and let thoſe that are next to be added be α, β, γ, δ, ε, &c. In Numbers near the Truth, let $r = \frac{\alpha\gamma - \beta\beta}{\alpha\beta - 2\alpha\gamma + \beta\gamma}$, and of the Quantities $\alpha \times \frac{\alpha + r\beta}{\alpha - \beta}$, $\overline{\alpha+\beta} \times \frac{\beta + r\gamma}{\beta - \gamma}$, $\overline{\alpha+\beta+\gamma} \times \frac{\gamma + r\delta}{\gamma - \delta}$, $\overline{\alpha+\beta+\gamma+\delta} \times \frac{\delta - r\varepsilon}{\delta - \varepsilon}$, $\overline{\alpha+\beta+\gamma+\delta+\varepsilon} \times \frac{\varepsilon + r\zeta}{\varepsilon - \zeta}$, &c. let the Differences be a, b, c, d, e, &c. Then in the neareſt Numbers let $s = \frac{ac - bb}{ab - 2ac + bc}$, and of the Quantities $a \times \frac{a + sb}{a - b}$, $\overline{a+b} \times \frac{b + sc}{b - c}$, $\overline{a+b+c} \times \frac{c + sd}{c - d}$, $\overline{a+b+c+d} \times \frac{d + se}{d - e}$, &c. let the Differences be A, B, C, D, &c. and let $t = \frac{AC - BB}{AB - 2AC + BC}$, and ſo proceed as far as you pleaſe. Then will $\alpha + \beta + \gamma + \delta + \varepsilon + \zeta$, &c.

ζ, &c. $= \alpha \times \frac{\alpha + r\beta}{\alpha - \beta} + a \times \frac{a + sb}{a - b} + A \times \frac{A + tB}{A - B}$, &c. And there will ſeldom be Occaſion to proceed beyond the two firſt Terms of this new Series.

As if the Value of this Series were deſired, $\frac{1}{1 \cdot 2} + \frac{1}{3 \cdot 4} + \frac{1}{5 \cdot 6} + \frac{1}{7 \cdot 8}$, &c. collect the firſt 21 Terms, the Sum of which I find to be ,6813, 8410, 1885. The Terms next to be added are $\alpha =$, 0005, 2854, 1226, $\beta =$, 0004, 8309, 1787, $\gamma =$,0004, 4326, 2411, $\delta =$,0004, 0816, 3265, &c. Hence it is that $r = 1$, nearly, and $\alpha \times \frac{\alpha + r\beta}{\alpha - \beta} =$, 0117, 6449, 6282, $a = -$,0000, 0017, 5096, $b = -$, 0000, 0014, 7410, $c = -$, 0000, 0012, 4986, &c. Whence $s = \frac{1}{3}$ nearly, and $a \times \frac{a + sb}{a - b} = -$, 0000, 0141, 8111, which becauſe of the negative Sign I ſubtract from $\alpha \times \frac{\alpha + r\beta}{\alpha - \beta}$, and there remains ,0117, 6307, 8171; this being added to the Sum before found, ,6813, 8410, 1885, gives the Number ,6931, 4718, 0056 for the Sum of the whole Series; which is true in the ninth Decimal. But before theſe two Corrections, the Sum was true in the firſt Figure only. If you have a Mind to come nearer the Mark, you may proceed to the following Approximations. If the Terms of the Series have different Signs, they are to be ſo join'd, that all may have the ſame. Thus in the Series $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9}$, &c. by collecting the Terms by two and two, it becomes $\frac{2}{1 \cdot 3} + \frac{2}{5 \cdot 7} + \frac{2}{9 \cdot 11} + \frac{2}{13 \cdot 15}$, &c. But here it is to be noted, that the Differences a, b, c, d, e, &c. as alſo A, B, C, D, &c. muſt be collected by ſubtracting the antecedent Quantities from the ſubſequent. And in all this Kind of Series, if p, q, r, repreſent three Terms following one another in Order, p the firſt, q the ſecond, and r the third; and the Rectangle $\frac{p + r}{2} \times q$ is not greater than pr; the Value of the Series will be infinitely great: But it will always be finite when the contrary happens. This Rule may ſometime fail, when the Terms p, q, and r are but little diſtant from the Beginning of the Series; but if they are ſuch Terms as are pretty remote from the Beginning, the Rule then becomes very ſafe and ſure.

To other Kinds of Series other Rules muſt be apply'd. Let there be a Series of Regular Polygons inſcribed in a Circle, the Radius being Unity; as

$H =$	2,0000,0000,0000,000	4
$G =$	2,8284,2712,4746,190	8
$F =$	3,0614,6745,8920,718	16
$E =$	3,1214,4515,2258,051	32
$D =$	3,1365,4849,0545,938	64
$C =$	3,1403,3115,6954,752	128
$B =$	3,1412,7725,0932,772	256
$A =$	3,1415,1380,1144,299	512

Now let the laſt Polygon be called A, the laſt but one B, the laſt but two C, and the reſt in their Order, but backwards, D, E, F, &c. and the Area of the Circle required will be

$$A + \frac{A-B}{3} + \frac{4A-5B+C}{3\cdot 15} + \frac{64A-84B+21C-D}{3\cdot 15\cdot 63} + \frac{4096A-5440B+1428C-85D+E}{3\cdot 15\cdot 63\cdot 255},$$

&c. where if for A, B, C, D, E, &c. are wrote their proper Values, the firſt four Terms will give the Area of the Circle 3, 1415, 9265, 3589, 790. Now this Series is general, and does not at all depend on the Nature of the Circle. It is applicable whenever the former Differences of the approximating Numbers are as it were quadruple of the latter. The Factors in the Denominators are the integral Powers of the Number 4 diminiſh'd by an Unit. Which being had, the Coefficients of the Letters in the different Terms are form'd by the continual Multiplication of the Numbers $1, \frac{n}{3}, \frac{n-3}{15}, \frac{n-15}{63}, \frac{n-63}{255}$, &c. where the laſt of the Factors of the Denominators muſt be ſubſtituted for n.

The laſt of the Quantities $x-1$, $2\sqrt[2]{x}-2$, $4\sqrt[4]{x}-4$, $8\sqrt[8]{x}-8$, $16\sqrt[16]{x}-16$, &c. is equal to the Logarithm of the Number x. For x write 2, and by a repeated Extraction of the Square Root, the following Numbers will ariſe.

$M =$ 1,0000,0000,0000,0000,
$L =$ 8284,2712,4746,1901,
$I =$ 7568,2864,0010,8843,
$H =$ 7240,6186,1322,0613,
$G =$ 7083,8051,8838,6214,
$F =$ 7007,0875,6931,7337,
$E =$ 6969,1430,7308,8294,
$D =$ 6950,2734,2438,7611,
$C =$ 6940,8641,2851,8363,
$B =$ 6936,1658,4759,4014,
$A =$ 6933,8182,9699,9493,

Let the laſt of the Numbers be called A, the laſt but one B, and ſo on backwards; and the Logarithm required will be $A + \frac{A-B}{1} + \frac{2A-3B+C}{1 \cdot 3} + \frac{8A-14B+7C-D}{1 \cdot 3 \cdot 7} + \frac{64A-120B+70C-15D+E}{1 \cdot 3 \cdot 7 \cdot 15}$, &c. The firſt five Terms will give 6931, 4718, 0559, 9457 for the Hyperbolic Logarithm of the Number 2. And how this Series proceeds *in infinitum* is eaſily infer'd from what we have ſaid of the former. It is alſo univerſal, having no Regard to the particular Properties of the Hyperbola.

Alſo this Differential Method may be extended to the Reſolution of Equations, and to many other Speculations which we forbear to mention here. And it contains the moſt general Foundations of Series, as perhaps I may ſhew in a ſhort Time, by applying it to the Reduction of Irrational Equations, as alſo Fluxional Equations.

A General Method of making Logarithms, *by Mr.* J. Craig, n. 328. p. 191.

XX. For the Perfection of this moſt uſeful Part of Arithmetick, this only ſeems to be wanting, the Diſcovery of ſome General Method for finding all the Logarithmical Series. Now ſuch is this that follows, being eaſy and genuine, as being derived from the very Nature of the Logarithms.

By the Letter l prefix'd to any Number is denoted (as is commonly known) the Logarithm of that Number. Now becauſe the Logarithm of any Number propoſed may be found in two Manners, therefore we ſhall conſtitute two Parts of this Logarithmotechny. In the firſt we deduce immediately the Logarithm from the Number. In the latter we derive the Logarithm of the propoſed Number from the known Logarithms of ſome antecedent Numbers.

Part 1. Let $a+1$ be any Number propoſed, and x its Logarithm to be found. Now by the Hypotheſis $x = l\,.\,\overline{a+1}$, which Equation may be call'd a general Canon. (1.) Let there be an Equation among Terms any how compoſed of a and y, with any other Numbers, combined in any Manner by Addition, Subtraction, Multiplication, Diviſion, or Extraction of Roots. (2.) By the Help of the Equation ſo aſſumed at Pleaſure, let a be exterminated out of the general Canon, and an Equation will be had expreſſing the Relation between the indeterminate Quantities x and y. (3.) By *Bernoulli*'s Rule let the Differential of this Equation be found, [or its Fluxion,] and by known Methods let the Integral [or Fluent] of this be found, expreſs'd by an infinite Series. This will give the Value of the Logarithm x required.

Example 1. Let it be aſſumed $a=y$; then by the general Canon $x=l.\overline{1+y}$, whoſe Fluxion is $\dot{x}=\frac{\dot{y}}{1+y}$. And the Fluent of this expreſs'd by an infinite Series is $x=y-\frac{1}{2}y^2+\frac{1}{3}y^3-\frac{1}{4}y^4+\frac{1}{5}y^5-\frac{1}{6}y^6$, &c.

Example 2. Aſſume $y=\frac{a}{a+2}$, whence $a+1=\frac{1+y}{1-y}$, and therefore by the general Canon $x=l.\frac{1+y}{1-y}$, the Fluxion of which is $\dot{x}=\frac{2\dot{y}}{1-yy}$, and the Fluent of this expreſs'd by a Series is $x=2$ into $y+\frac{1}{3}y^3+\frac{1}{5}y^5+\frac{1}{7}y^7$, &c. Where the Number 2 prefix'd muſt be multiply'd into all the Terms of the Series. Nor is there Occaſion to add more Examples here, ſince from hence it appears, how innumerable Logarithmical Series may be found, which, without any Reſpect to the Logarithms of other Numbers, exhibit the Logarithm of the Number propoſed. *Q. E. I.*

Lem. 1. Let z be the Logarithm of any Fraction $\frac{b}{a+1}$, x the Logarithm of the Denominator $a+1$; then will $l.\overline{b-z}=x$. Or if z is the Logarithm of the Fraction $\frac{a+1}{b}$, it will be $l.\overline{b+z}=x$.

Lem. 2. *Let* e be the Exponent of any Power of the Number b; then will $l.b^e=e\times l.b$. Therefore the Logarithm of the Number b^e, and the Exponent e being given, the Logarithm of b will alſo be given. Both theſe *Lemmata* are plain from the Nature of Logarithms.

Part 2. Let $a+1$ be the Number, as before, whoſe Logarithm is to be found, and let b^e be a Number produced by the Multiplication of Numbers, the greateſt of which is leſs than $a+1$. And let z be the Logarithm of the Fraction $\frac{b}{a+1}$, that is, $z=l.\frac{b}{a+1}$. And let this Equation be called the general Canon. Then (1.) for b let there be taken

a

a Quantity any how compoſed of a, and any determinate Numbers, and let this Value of the Number b, ſo taken at Pleaſure, be ſubſtituted in the Fraction $\frac{b}{a+1}$, whence it will be expreſs'd by a and given Numbers. (2.) Let there be any Equation between y and a, with Numbers taken at Pleaſure; and by the Help of this let a be exterminated out of the general Canon; whence an Equation will be had, expreſſing the Relation between the Indeterminates x and y. (3.) By *Bernoulli*'s Rule let the Fluxion of this Equation be found, and then by known Methods find the Fluent of this expreſs'd by an infinite Series, which will give the Logarithm z of the Fraction $\frac{b}{a+1}$. And when z is found, the Logarithm $x = l.\overline{b-z}$ of the propoſed Number $a+1$ will be had by *Lem.* 1. For by Hypotheſis b^c is produced by the Multiplication of Numbers, the greateſt of which is leſs than $a+1$; and by Hypotheſis the Logarithms of all Numbers are known, which are leſs than the propos'd Number $a+1$. Therefore alſo the Logarithm of the Number which is the Product of all, or b^c; and therefore (by *Lem.* 2.) the Logarithm of b will be given.

Example 1. Aſſume if you pleaſe $b = a$, whence $z = l.\frac{a}{a+1}$. Then (by Art. 2.) take *ad libitum* $y = 2a+1$, by which let a be exterminated, and it will be $z = l.\frac{y-1}{y+1}$, whoſe Fluxion is is $\dot z = \frac{2\dot y}{yy-1}$. The Fluent of this, expreſs'd by a Series, is $z = -2$ into $\frac{1}{y} + \frac{1}{3y^3} + \frac{1}{5y^5} + \frac{1}{7y^7}$, &c. whence by *Lem.* 1.

$$x = l.b + 2 \times \overline{\frac{1}{y} + \frac{1}{3y^3} + \frac{1}{5y^5} + \frac{1}{7y^7} + \frac{1}{9y^9}}, \text{ \&c.}$$

Example 2. Make $b = \sqrt{aa+2a}$, whence $z = l.\frac{\sqrt{aa+2a}}{a+1}$. Take alſo at Pleaſure $y = aa+2a$, whence $z = l.\frac{1}{y}\sqrt{yy-4}$, of which the Fluxion is $\dot z = 4\dot y \times \overline{y^3-4y}|^{-1}$, and the Fluent of this is $z = -2$ into $\frac{1}{y^2} + \frac{2^2}{2y^4} + \frac{2^4}{3y^6} + \frac{2^6}{4y^8}$, &c. whence by *Lem.* 1.

$$x = l.b + 2 \times \overline{\frac{1}{y^2} + \frac{2^2}{2y^4} + \frac{2^4}{3y^6} + \frac{2^6}{4y^8} + \frac{2^8}{5y^{10}}}, \text{ \&c.}$$

Example 3. Make $b=\sqrt{aa+2a}$, as in the foregoing, but now aſſume $yy=2aa+4a+1$; if by theſe two Equations are exterminated b and a out of the general Canon, it will be $z=l.\frac{\sqrt{yy-1}}{\sqrt{yy+1}}$, of which the Fluxion is $\dot{z}=2y\dot{y}\times\overline{y^4-1}|^{-1}$, of which the Fluent expreſs'd by a Series is $z=-\frac{1}{y^2}-\frac{1}{3y^6}-\frac{1}{5y^{10}}-\frac{1}{7y^{14}}$, *&c.* Therefore by *Lem.* 1. $x=l.b+\frac{1}{y^2}+\frac{1}{3y^6}+\frac{1}{5y^{10}}+\frac{1}{7y^{14}}+\frac{1}{9y^{18}}$, *&c.*

But it muſt be obſerved, that the Number 2 prefix'd in the Series of the firſt and ſecond Examples, is ſuppoſed to be multiply'd into all the Terms of the following Series. And that like Series may be derived from $z=l.\frac{a+1}{b}$ in the ſame Manner; but then $x=l.\overline{b+z}$, as appears from the ſecond Part of the firſt *Lemma.* Therefore from hence it appears very plain, that the Logarithmotechny now explain'd is very eaſy and genuine, and ſo general, that by theſe two Ways innumerable Series may be found, exhibiting the Logarithm of any Number propoſed. For we may aſſume innumerable Equations at Pleaſure, expreſſing the Relation between y and a, every one of which will give us a new Logarithmic Series. Yet Care ſhould be taken that ſuch Equations may be aſſumed, that ſhall cauſe the Terms to converge as faſt as may be, ſo that the Logarithm may be found with the leaſt Trouble poſſible. To perform this, the Series exhibited in the laſt Examble will be very proper, which is the ſame as that given by the learned Dr. *Halley*, the firſt Inventer of it, in his very elegant Method of conſtructing the Logarithms.

Here by the Way I deſire the Reader to take Notice, that the Curve, which is derived from our Analyſis of the Problem, concerning the Length of Curve-Lines, publiſhed in the Philoſophical Tranſactions for the Year 1708, is the ſame with that propoſed. As I was wholly intent about the Analyſis, I took no Notice of the Coincidence of the Curve propoſed with that which was found, till the learned D. *Jo. Bernoulli* inform'd me of it, in his Letter to Mr. *Will. Burnett*, F. R. S. By which alſo that learned Man was pleaſed fully to ſatisfy all my Objections againſt his *Creeping Motion*; as I now readily own, out of that pure Love which I bear to Truth.

XXI. *Log.*

A New *Method for making* Logarithms, *communicated by Mr.* J. Long, n. 339. p. 52.

XXI.

Log.	*Nat. Num.*	*Log.*	*Nat. Num.*
0,9	7,943282347	0,00009	1,000207254
0,8	6,309573445	0,00008	1,000184224
0,7	5,011872336	0,00007	1,000161194
0,6	3,981071706	0,00006	1,000138165
0,5	3,162277660	0,00005	1,000115136
0,4	2,511886432	0,00004	1,000092106
0,3	1,995262315	0,00003	1,000069080
0,2	1,584893193	0,00002	1,000046053
0,1	1,258925412	0,00001	1,000023026
0,09	1,230268771	0,000009	1,000020724
0,08	1,202264435	0,000008	1,000018421
0,07	1,174897555	0,000007	1,000016118
0,06	1,148153621	0,000006	1,000013816
0,05	1,122018454	0,000005	1,000011513
0,04	1,096478196	0,000004	1,000009210
0,03	1,071519305	0,000003	1,000006908
0,02	1,047128548	0,000002	1,000004605
0,01	1,023292992	0,000001	1,000002302
0,009	1,020939484	0,0000009	1,000002072
0,008	1,018591388	0,0000008	1,000001842
0,007	1,016248694	0,0000007	1,000001611
0,006	1,013911386	0,0000006	1,000001381
0,005	1,011579454	0,0000005	1,000001151
0,004	1,009252886	0,0000004	1,000000921
0,003	1,006931669	0,0000003	1,000000690
0,002	1,004615794	0,0000002	1,000000460
0,001	1,002305238	0,0000001	1,000000230
0,0009	1,002074475	0,00000009	1,000000207
0,0008	1,001843766	0,00000008	1,000000184
0,0007	1,001613109	0,00000007	1,000000161
0,0006	1,001382506	0,00000006	1,000000138
0,0005	1,001151956	0,00000005	1,000000115
0,0004	1,000921459	0,00000004	1,000000092
0,0003	1,000691015	0,00000003	1,000000069
0,0002	1,000460623	0,00000002	1,000000046
0,0001	1,000230285	0,00000001	1,000000023

This Table is what I ſometimes make Uſe of for finding the Logarithm of any Number propoſed, and *vice verſâ*, for finding the Number correſponding to a Logarithm given. For Inſtance: Suppoſe I had Occaſion to find the Logarithm of 2000, I look in the firſt Claſs of my Table, (the whole Table conſiſts of 8 Claſſes) for the next leſs to 2, which is 1.295262315, and againſt it is 3, which conſequently is the firſt Figure of the Logarithm ſought. Again, dividing the Number propoſed 2, by 1.995262315, the Number found in the Table, the Quotient is 1.002374467; which being look'd for in the ſecond Claſs of the Table, and finding neither its equal, nor a leſſer, I add 0 to the Part of the Logarithm before found, and look for the ſaid Quotient 1.002374467 in the third Claſs, where the next leſs is 1.002305238, and againſt it is 1, to be added to the Part of the Logarithm already found; and dividing the Quotient 1.002374467, by 1.002305238, laſt found in the Table, the Quotient is 1.000069070; which being ſought in the fourth Claſs gives 0, but being ſought in the fifth Claſs gives 2, to be added to the Part of the Logarithm already found; and dividing the laſt Quotient by the Number laſt found in the Table, *viz.* 1.000046053, the Quotient is 1.000023015, which being ſought in the ſixth Claſs, gives 9 to the Part of the Logarithm already found: and dividing the laſt Quotient by the new Diviſor, *viz.* 1.000002072, the Quotient is 1.000000219, which being greater than 1.000000115, ſhews that the Logarithm already found, *viz.* 3.3010·99 is leſs than the Truth by more than half an Unit; wherefore adding 1, you have *Briggs*'s Logarithm of 2000, *viz.* 3.3010300.

If any Logarithm be given, ſuppoſe 3.3010300, throw away the Characteriſtic, then over-againſt theſe Figures 3...0..1...0..3..6..0, you have in their reſpective Claſſes 1.995262315.....0.....1.002305238......0.....1.000069080....0...0 which multiplied continually into one another, the Product is 2.0000000019966, which by reaſon the Characteriſtic is 3, becomes 2000.000019966, that is, 2000, the natural Number deſired. I ſhall not mention the Method by which this Table is framed, becauſe you will eaſily ſee that from the Uſe of it.

It is obvious to the intelligent Reader, that theſe Claſſes of Numbers are no other than ſo many Scales of mean Proportionals. In the firſt Claſs, between 1 and 10; ſo that the laſt Number thereof, *viz.* 1.258925412 is the tenth Root of 10, and the reſt in order aſcending are the Powers thereof. So in the ſecond Claſs, the laſt Number 1.023292992 is the hundredth Root of 10, and the reſt in the ſame Manner are Powers thereof. So 1.002305238 in the third Claſs, is the tenth Root of the laſt of the ſecond, and the reſt its Powers, *&c.* Or, which is all one, each Number in the preceding Claſs, is the tenth Power of the correſponding Number in the next following Claſs: Whence 'tis plain, that to conſtruct theſe Tables requires no more than one Extraction of the fifth or ſurſolid Root for each Claſs, the reſt of the Work being done by the common Rules of Arithmetick; and for extracting the fifth Root, you will find more than one very compendious Rule in *Num.* 210. of theſe *Tranſactions*, if any one ſhall deſire to examine the *computus* of theſe Tables.

The Proceſs is exactly the Reverſe of Mr. *Briggs*'s Doctrine, in *Cap.* XII. of his *Arithmetica Logarithmica Vlacq*'s Edition; and had *Briggs* been apprized hereof, it would have greatly eaſed the Labour of deducing the Logarithms of the firſt prime Numbers, which appear to have coſt him ſo much Pains.

A Letter of Mr. l'Abbé Conti *to Mr.* Leibnitz, *concerning the* Invention *of the Method of* Fluxions, n. 359. p. 923.

XXII. 1. I have defer'd till now to anſwer your Letter, becauſe I had a Mind to accompany my Anſwer with that which Mr. *Newton*[a] has lately made, to the Poſtſcript which you have added to it. I ſhall not enter into the Particulars of the Diſpute between you and Dr. *Keil*, or rather Mr. *Newton*. I can only relate Matters of Fact, what I have ſeen, and what I have read, and what I ſhall ſtill ſee and read, in order to make a true Judgment of the Affair.

I have read with great Attention, and without the leaſt Prepoſſeſſion, the *Commercium Epiſtolicum*, and the little Book[b], which contains an Extract from it. I have ſeen at the *Royal Society* the original Papers of the Letters of the *Commercium*; a ſmall Letter[c] wrote in your Hand to Mr. *Newton*; and an old Manuſcript[d] that Mr. *Newton* ſent to Dr. *Barrow*, and which Mr. *Jones* has lately publiſh'd.

From all which I collect, that if we leave out of the Diſpute all foreign Digreſſions, all we have to do is to examine, whether Mr. *Newton* had the *Calculus* of Fluxions, or of Infiniteſimals, before you, or whether you had it before him. You publiſh'd it firſt, that is true; but you have likewiſe own'd, that Mr. *Newton* had given great Hints of it, in the Letters that he had wrote to Mr. *Oldenburg*, and to others. This is proved at full Length in the *Commercium*, and in the Extract from it; what is your Anſwer to this? This is what the Publick wants, in order to make a ſure Judgment in this Matter.

Your Friends expect your Anſwer with much Impatience, and it is their Opinion, that you cannot avoid returning ſome Anſwer; if not to Dr. *Keil*, yet at leaſt to Mr. *Newton* himſelf, who gives you a Challenge in expreſs Terms, as you will ſee in his Letter.

---

[a] In his Letter dated *Feb.* 26. 1715-16. *ſt. vet.* and printed at the End of *Raphſon*'s Hiſtory of Fluxions.

[b] Printed in the *Philoſophical Tranſactions*, N. 342. and in Tome VII. *du Journal Litteraire*.

[c] Dated 17 *March* 1693. and printed at the End of *Raphſon*'s Hiſtory of Fluxions.

[d] Entituled, *Analyſis per Series numero terminorum infinitas*.

I ſhould be glad to ſee you on good Terms with one another. The Publick receives but ſmall Advantage from ſuch Diſputes, but rather loſes for many Ages all the Improvements, which ſuch Diſputes deprive it of.

His Majeſty has been pleaſed to lay his Commands upon me, to acquaint him with all that has paſſed between Mr. *Newton* and you. I did it to the beſt of my Power, and I wiſh it might be with Succeſs to you both.

Your Problem has been reſolved very eaſily, and in a little Time. Several Geometricians, both at *London* and *Oxford*, have given a Solution of it. It is general, for it extends to all Sorts of Curves, whether Geometrical or Mechanical. The Problem is propoſed a little equivocally; but I think M. *de Moivre* is not miſtaken, when he ſays, that our Ideas of it ſhould be reſtrained to a Series of Curves. For Example, we may ſuppoſe it to have the ſame Subtangent to the ſame Abſciſs; which will not only agree to the Conic Sections, but to infinite other Curves, as well Geometrical as Mechanical. Other Suppoſitions might be made, to fix the Idea of it.

I ſhall ſpeak to you another Time concerning Mr. *Newton*'s Philoſophy. We muſt firſt agree upon the Method of Philoſophizing, and very carefully diſtinguiſh between the Philoſophy of Mr. *Newton*, and the Conſequences that many are apt to draw from it, though very raſhly. Many Things are aſcribed to this great Man, which he does not own, as he has proved to thoſe *French* Gentlemen, who came to *London*, on Account of the great Eclipſe.

I am, with all poſſible Reſpect,
London, *Sir*, your, *&c.*
March 1716.

N. B. *Mr.* l'Abbé Conti *ſpent ſome Hours alſo in looking over the old Letters and Letter Books kept in the Archives of the* Royal Society, *to ſee if he could find any Thing which made either for Mr.* Leibnitz, *or againſt Mr.* Newton, *and had been omitted in the* Commercium Epiſtolicum Collinii & aliorum; *but could find nothing of that Kind.*

SIR, *Hanover*, *Apr.* 14, 1716.

Mr. Leibnitz's *Anſwer.*

2. Not to make you wait, I ſhall tell you before Hand, that I have anſwer'd already to the Letter which I had the Honour of receiving from you, and at the ſame Time to that which Mr. *Newton* has wrote to you. I have ſent the Whole to Mr. *Remond* at *Paris*, who will not fail of tranſmitting them to you. I made uſe of this Way, that I might have impartial and intelligent Witneſſes of our Diſpute: And Mr. *Remond* will alſo communicate them to others. I have ſent him at the ſame Time, a Copy of your Letter, and of that of Mr. *Newton*. After this you will be able to judge, whether the Petulance of ſome of your new Friends gives me much Diſturbance.

As to the Problem, of which ſome among them have thought fit to reſolve ſome particular Caſes, to fix their Ideas, as they call it; it is probable they have pitched upon ſome eaſy Caſes. For there are ſome ſuch among the tranſcendent Curves, as well as among thoſe that are common. But the Buſineſs is to find a general Solution. This Problem is no new one. Mr. *John Bernoulli* has already propoſed it for the Month of *May* in the *Leipſic* Journal, 1697. p. 211. And as Mr. *Facio* deſpiſed what we had done, the Propoſal was repeated for him, and for others like him, in the Journal of *May* 1700. p. 204. It may ſtill ſerve to this Day, to ſhew ſome People, how far they are gone in Methods, and whether they have gone as far as we. And, in the mean Time, till they find out the Means of arriving at a general Solution, they may try what they can do in fixing their Ideas upon a particular Caſe, which we here propoſe to them in the Paper hereto annexed. Its Solution proceeds ſtill from the ſame Mr. *Bernoulli*. So I hope you will have the Goodneſs, not to give yourſelf up too much to the Inſinuations of thoſe who are oppoſite to us; as when they would make you believe, that our Problem was eaſy to them. *I am, SIR, with much Zeal, yours*, &c.

A Problem containing a particular Caſe of the general Problem, for finding a Series of Curves, every one of which is perpendicular to another Series of Curves.

Fig. 34. *Upon the right Line* AG, *as an Axis, from the Point* A *any Number of Curves being conſtructed, ſuch as* ABD, *of ſuch a Nature, that the Radius of Curvature* BO, *drawn from all the Points* B *of the ſeveral Curves, may be cut by the Axis* AG *in* C, *alway in the ſame given ratio: That is, that it may be as* BO *to* BC, *ſo is* m *to* n. *Now let Trajectories be conſtructed ſuch as* ENF, *that may cut the former Curves* ABD *at right Angles.*

Fig. 35. *Thus far this Letter.*] Mr. *Leibnitz* firſt propoſed the general Problem to M. *l'Abbé Conti* in theſe Words; *To find a Line* BCD, *which may cut at right Angles all the Curves of a determinate Series of the ſame Kind; for Example, all the Hyperbola's,* AB, AC, AD, *which have the ſame Vertex and the ſame Center; and this by a general Method.* And in the *Acta Euriditorum* for *October*, 1698. p. 470, 471. he calls the Curves in this determinate Series, *Curves given as to their Ordinates, and given in Poſition, and given in Poſition as to their Ordinates.* And by all this, the Series of Curves to be cut is given, and nothing more is to be found, than the other Series which is to cut it at right Angles. But Mr. *Leibnitz* being told, that his Problem was ſolved, he changed it into a new one, of finding both the Series to be cut, and the other Series which is to cut it. And the particular Problem, propoſed in this Letter, is a ſpecial Caſe, not of the general Problem firſt propoſed, as it ought to have been, but of this new double Problem. And the firſt Part of this double Problem, (*viz.* by any given Property of a Series of Curves to

find the Curves) is a Problem harder than the former, and of which a general Solution is not yet given. Mr. *Leibnitz*, in a Letter to Mr. *John Bernoulli*, dated 16 *December*, 1694. and publiſhed in the *Acta Eruditorum* for *October*, 1698. p. 471. ſet down his Solution of the Problem, when the given Series of Curves is defined by a finite Equation, expreſſing the Relation between the Abſciſs and Ordinate. The ſame Solution holds, when the Equation is a converging Series, or when the Property of the Curve to be cut, can be reduced to ſuch an Equation, by the *Analyſis* by Series that are infinite in the Number of their Terms. But Mr. *Leibnitz* was for ſolving the Problem without converging Series.

Dr. Taylor's *Apology againſt* J. Bernoulli, n. 360. p. 955.

XXIII. In an Epiſtle for an eminent Mathematician, *Act. Lipſ.* 1716. I am accuſed of Plagiariſm, as if I arrogated to myſelf the Inventions of *Bernoulli* and others. Let them produce their Examples, and then they ſhall have an Anſwer. 'Tis true I have treated of many Things in common with others, but I have by no Means uſed other Mens Inventions as my own. I have every where uſed by own Analyſis, (if you will except the Problem of Iſoperimeters, of which Mention ſhall be made hereafter) that it cannot be ſaid in any wiſe I have cheated others. They ſhould have named their Authors, from whom I have taken my Methods. I have ſo great a Veneration for the illuſtrious Names of *Huygens*, *de l'Hoſpital*, *Varignon*, *Leibnitz*, and others, that I cannot tell but that I have err'd on the contrary Side, when I may ſeem to have been wanting to myſelf, who always thought it an Honour to myſelf to quote ſuch Men as theſe. Perhaps there might be a little Lazineſs in the Matter, that being wholly intent upon Things, I neglected little Pieces of Hiſtory. Yet I hoped I could not fall under the Suſpicion of ſuch a Fraud, ſince the celebrated Works of ſuch great Men would eaſily diſcover it. What Problems I have treated of in common with *Bernoulli* are, of the Funicularia, of the Center of Oſcillation, and of Iſoperimeter's. In the two firſt I have uſed my own Analyſis entirely. In the Iſoperimeters I uſed the Analyſis of the Author *James Bernoulli*, a Man very deſerving in Mathematicks, to whom I now pay the Honour which is due to him. My Solution of the Problem concerning the Center of Oſcillation was communicated to my Friends ever ſince the Beginning of the Year 1712, as I can appeal to the manuſcript Letters of Dr. *Keil* for Witneſſes. As alſo my Book was in the Cuſtody of the Royal Society, and communicated to almoſt all our Mathematicians, from the Month of *April* of the Year 1714; which I thought neceſſary to mention here, leſt *Bernoulli* ſhould claim alſo that Solution to himſelf. His two Solutions are extant [a], both publiſhed in the ſame Year; the latter of which ſo perfectly agrees with mine, as to its Principles, that you would ſwear they were both invented by the ſame Perſon. The Matter of the Iſoperimeter's was firſt invented by *James Bernoulli*, as hinted above. His Solution with the Analyſis is extant in the *Leipſic* Journal for the Year 1701. His Brother's Analyſis is extant in the Memoirs of the Royal Academy of Sciences for the Year 1706. A Solution is alſo extant in my Book. *Bernoulli* has lately publiſhed a Commentary about the ſame Subject in the *Leipſic* Acts for the Year 1718. There, leaſt he ſhould ſeem to do the ſame Thing over again [b], he ſpitefully endeavours to detract, not only from mine, but from his Brother's Solutions alſo, objecting Prolixity to his Brother [c], and Obſcurity to me [d]. He promiſes every Thing that is great of thoſe his new Undertakings [e], and by the Help of a certain Principle, fetch'd from the Law of Uniformity, which nobody has hitherto obſerved, he will compleat the whole Matter almoſt without Calculation, and with very little Trouble. But I know not by what Fatality, in this Matter about the Iſoperimeters, *Bernoulli* never finds the Gods propitious. For *firſt*, that former Analyſis of his from Beginning to End makes only one continued Blunder. *Secondly*, that ſo much boaſted Principle of his, fetch'd from the Law of Uniformity, which nobody has hitherto obſerved, (for ſo he boldly affirms) has already been obſerved by me. *Laſtly*, the Analyſis which he here exhibits as a new one, is merely that of his Brother. For it is the Precepts which make the Analyſis, according to which the Calculation is afterwards performed; which is not itſelf the Analyſis, but only the Inſtrument of the Analyſis. The Precepts being once laid down, every one eaſily performs the Calculation, each in his own Way, one more copiouſly, another cloſer or neater, according as his Genius directs.

---

[a] One in the *Leipſic* Journal of *June*, the other in the Memoirs of the *French* Academy for *Auguſt*.

---

[b] P. 16, &c. Therefore for theſe and other Reaſons, I ſhall not ſeem to do the ſame Thing over again, &c.

[c] Here the Reader will find no Rocks, which the operoſe Analyſis of my Brother throws in his Way, and the Intricacies and Thorns of third Differences, with which the Way is every where beſet; he will find no ſuch Things in my Method.—— Neither has he to fear the Prolixity of my Brother's Calculation, nor the Obſcurity of *Taylor's*, which is equally offenſive and troubleſome, p. 18. —— which my Brother has deduced by his moſt operoſe Analyſis —— not only thoſe Things which were formerly propoſed by my Brother with great Pomp, and ſolved with no leſs Labour and Difficulty, I have ſolved by the Law of Uniformity alone, without any Analytical Calculus, &c.

[d] See the foregoing Note — alſo what is now taken from p. 18.

[e] I truſt with Joy that the Publick will give him Thanks, that I have had Occaſion of publiſhing ſuch Things now, which perhaps, with many other Things, might have lain buried for ever in my Papers, altho' they will not a little enlarge the Boundaries of the ſublimer Geometry, p. 17. What was omitted there by Incogitancy, I ſhall here make Amends for, by a new Method of Solution, which diſpatches Problems with ſingular Facility, not only all thoſe which my Brother propoſed concerning Iſoperimeters, but innumerable others of a like Kind, *ib.* —— by Help of a certain Principle derived from the Law of Uniformity, which no one has hitherto obſerved, by the Inſpection of the Figure alone, and almoſt without any Calculation, I ſhall deduce Equations for Curves required, that offer themſelves as it were of their own Accord, &c. as in Note [c]. I ſhall not ſeem to do the ſame Thing over again, if in this Argument, which is difficult of itſelf, I ſhew a Way or Method that is ſhort, plain, clear, and eaſy, by which any one, endued but with a moderate Capacity, may arrive at thoſe abſtruſe Truths, not upon the Credit of others, but be convinced with his own Eyes; ſo that, &c, as in Note [c].

It muſt not be denied, that *Bernoulli* has made the Calculation more neat and elegant, but he has done it in his Brother's Analyſis and not his own. Nor is it to be doubted but that his Brother, if he had lived till now, would have illuſtrated this Matter as well. We ſaid before, that the Analyſis conſiſts wholly in the Precepts; but all the Precepts are his Brother's. For that he conſiders a little Arch of the Curve required, as compoſed of three little Elementary right Lines, is wholly owing to his Brother, as he himſelf has confeſs'd[f]. That from the given Length of that little Arch he ſeeks the ratio of the Differences of the Ordinates in his Lemma's, is from his Brother. That he ſeeks the ſame ratio over again, by ſuppoſing the little naſcent Area, compoſed of the Functions as he calls them, to be either the greateſt or leaſt, is from his Brother. *Laſtly*, that from that double Expreſſion of that ſame ratio he obtains the Equation, by which the Nature of the Curve ſought is determined, is from his Brother. But theſe are the Things which conſtitute the Solution: Therefore the Solution is entirely his Brother's. I ſaid that I heretofore made Uſe of that Principle, which *Bernoulli* arrogates to himſelf with ſo much Oſtentation. Here are two Examples of it in the ſame Page. In Page 113. of my Book are found theſe,

$\frac{m_{,}}{R_{,}} = \frac{m}{R}$. But $\frac{m_{,}}{R_{,}}$ is a new Value of $\frac{m}{R}$. Whence $\frac{m}{R}$ will be a given Quantity. Here it is as clear as the Light, that in this Place, from obſerving the Uniformity of the Expreſſions $\frac{m_{,}}{R_{,}}$ and $\frac{m}{R}$, I concluded that $\frac{m}{R}$ is a given Quantity. I did the ſame in what follows.

Suppoſe $\frac{m\,n_{,,}}{n\,R_{,}} = \frac{\dot{m}}{R}$, that is $\frac{m\,n_{,,}\,n_{,}}{R_{,}} = \frac{\dot{m}\,n_{,}\,n}{R}$, *&c.* where that the Uniformity might appear between the *Formulæ*, $\frac{m\,n_{,,}\,n_{,}}{R_{,}}$ and $\frac{\dot{m}\,n_{,}\,n}{R}$, I transform'd the Equation. I fancy you will now perceive how happily I have penetrated into *Bernoulli*'s profound Myſteries. Will he ſay that this is obſcure too?

---

[f] For this I ſhall uſe, (as he has done in his Analyſis) the Notion of a very ſmall Arch, *&c.* p. 18.

Now I come to the firſt Part of my Undertaking, which is to ſhew, that *Bernoulli*'s former Analyſis was extremely corrupt. *Firſt* by a Subſtitution, which is ridiculous enough, fetch'd I ſuppoſe from his profound Speculations, he transforms the Equation $FO \times \Delta RO = \varphi\omega \times \Delta\rho\omega$ into this $FO \times \Delta PF = \varphi\omega \times \Delta\pi\varphi$; which in a particular Caſe, (that is, when the Functions are as the Squares of the Ordinates) comes to this, that at the ſame Time $FO \times RO = \varphi\omega \times \rho\omega$, and $FO \times PF = \varphi\omega \times \pi\varphi$. Whence it follows that $PF . RO :: \pi\varphi . \rho\omega$. But this is impoſſible, becauſe it is $PF < RO < \rho\omega < \pi\varphi$, or elſe $PF > RO > \rho\omega > \pi\varphi$; neither of which can be reconciled with the propoſed Analogy. For if $PF < RO < \rho\omega < \pi\varphi$ by the Analogy it will be alſo $\pi\varphi < \rho\omega$ (becauſe of $PF < RO$) contrary to the Hypotheſis. Or if $PF > RO > \rho\omega > \pi\varphi$, by the Analogy it will be alſo $\pi\varphi > \rho\omega$, contrary to the Hypotheſis. *Secondly*, he very unskilfully ſuppoſes the Curvature in F to be to the Curvature in ω, as ωO to FO; ſince there is nothing in the whole Analyſis that can reſtrain this Property to the Point O, rather than to any other Point ω in the little Arch $FO\omega\varphi$ taken any where: Nor indeed can Curvitude be eſtimated in ſo ridiculous a Manner. *Thirdly*, with but little Skill he makes $mn = \ddot{x}$, $nl = \ddot{y}$, and $ml = \frac{\dot{t}\ddot{y}}{\dot{x}}$; when they ought to be $mn = \frac{1}{2}\ddot{x}$, $nl = \frac{1}{2}\ddot{y}$, and $ml = \frac{\dot{t}\ddot{y}}{2\dot{x}}$. *Laſtly*, what is worſt of all, to theſe very erroneous Principles he has affix'd a very perfect Concluſion. I ſay this in the firſt Problem; for in the ſecond the Off-ſpring is more worthy of ſuch Parents. You imagine that I am only expoſing ſome of *Bernoulli*'s old obſolete Blunders: But it is not ſo, for thus he goes on. "All theſe "Things I have laid-by a good While, and now diſcuſſing them over "again very accurately, I have weigh'd them in the Scale of a ſevere "Examination [g]. And it is to be noted, that the Solution of the firſt "Problem, in my Paper inſerted in the Memoirs of the Academy, "p. 235. is perfectly right [h]." Therefore he has again adopted his old Miſtakes. Now perhaps any one would enquire, by what Right he pretends to the firſt Rank in the ſublimer Analyticks, with ſuch a ſtubborn Ambition? So that nobody can make any Advances in it, but he muſt be immediately accuſed of having penetrated into *Bernoulli*'s profounder Science [i]. Whence does it appear to be true, what has been lately affirm'd by ſomebody, that the Rules now extant in the Treatiſe *Analyſe des Infiniment Petits*, were firſt derived from *Bernoulli* [k]? That the Praiſe uſually given to the moſt excellent Marquis *de l'Hoſpital*, muſt be now transfer'd to his Preceptor? Is ſuch a Man fit to teach others the Rules of Differencing Differences [a]? With many other Things which there is no Occaſion now particularly to enumerate.

---

[g] P. 16. [h] P. 17. [i] P. 18. See alſo Ep. for an eminent Mathematician, and *Bernoulli*'s own Writings almoſt every where.

[k] He allows the Marquis *de l'Hoſpital* underſtood that Method, and knows that illuſtrious Perſon learn'd it from the great *Bernoulli*; and is well aſſured, that the Rules in the ſaid Book (the Analyſis of infinitely ſmall Quantities) owe their Original to the famous *Bernoulli*. *Act. Leipſ. Ann.* 1718. p. 464.

A Vindication of Mr. J. Gregory; *by Dr.* D. Gregory, n. 308. p. 2236.

XXIV. Twelve Years ago I undertook the Defence of that learned Man Mr. *James Gregory* my Uncle, againſt the Calumnies of Abbot *Galloyſe*; who alſo impeached before the learned World the great Dr. *Barrow* [b], as if he had ſtolen from *Robervall* his Propoſitions concerning the Transformation of Curves. Now ſince *Galloyſe* has thought fit to revive the ſame Controverſy again [c], give me Leave again to vindicate my Uncle's Reputation.

Robervall lived ſeven Years after *Gregory*'s Book was publiſhed. He that was catching at every little Advantage, was challenging every Thing to himſelf, and would leave no one in quiet Poſſeſſion of his own; would he ſuffer himſelf to be rifled of his Propoſitions, while he was alive and had the Uſe of his Eyes? But *Galloyſe* ſays, he did not ſee it, he read no new Book all that Time, he patiently ſuffer'd himſelf to be robb'd of all his Diſcoveries, he gave up his Fame together with his Mathematicks. I wonder with what Face he can throw out ſuch Fictions as theſe, which can ſo eaſily be refuted. There is ſo little Truth in his Aſſertion, that from the Year 1668, *Robervall* lived in Retirement, remote from the Converſation of learned Men, and had renounced his Mathematical Studies; that from the Year 1670, he was a Profeſſor of Mathematicks in the Academy of *Paris*, and communicated to the Royal Academy of Sciences his Invention of a *new Balance*, as their Acts teſtify, which were publiſhed for that Year [d]. Therefore *Robervall* was preſent at the Aſſemblies of the Academicians; and if he then read nothing himſelf, yet can it be thought he heard nothing in Converſation about Mr. *Gregory*'s Inventions, which were then ſo celebrated in *France*? Did he hear nothing about them from Mr. *Huygens*, who at that Time diſputed very eagerly againſt *Gregory* among the Academicians [e]? But if there was no Familiarity between him and *Huygens*, as *Galloyſe* affirms, (perhaps becauſe he was diſpleaſed that *Huygens* has found out the chief and moſt uſeful Property of his *Trochoid*) could he hear nothing for the whole Space of ſeven Years, from all the reſt of the Academicians? Or if he did hear, did he make no Complaint to his Brethren and Friends? Who can believe he had ſuch a Contempt for Fame, that has but once heard of his Squabbles with the *Italians*, with his own People, and with every body? If of a ſudden he was become ſo indolent, and ſo indifferent to Reputation, that he could eaſily ſuffer to ſee all his Diſcoveries aſcribed to others; and that what he had happily invented rather to lie dormant in his *Ecritoire*, than to bring them to Light; How could it be that *Gregory* ſhould ſteal theſe Things from him? Let us ſee by what Strength of Argument *Galloyſe* proceeds to fix this Accuſation upon him. *Firſt* (ſays he) *it appears*[g], *that this Method for the Transformation of Curves, which was invented by* Robervall, *was known in* Italy *before the Year* 1668; *for* Torricellius, *who died An.* 1647, *teſtifies in his Letters, that it was communicated to him by* Robervall. Secondly, *the Adverſary, however unwilling, is obliged to confeſs, that this Method is the ſame with that of* Gregory. Thirdly, *it muſt therefore appear very probable, that* Gregory, *when upon his Travels in* Italy, *might learn this Method from the* Italians, *which had been ſo long known in* Italy.

---

[a] In the mean Time it may be concluded, that he, together with Mr. *Newton* at the Beginning, remain'd in that Error, till at laſt they were deliver'd from it by the Uſe of he *Calculus Differentialis*, and were taught the *Rules of Differencing Differences by the famous* Bernoulli, *ib.* p. 465.

[b] *Memoirs of the Academ.* for 1693.

[c] *Memoirs of the Acad.* for 1703.

[d] *Journal des Sçavans, An.* 1670.

[e] *Journal des Sçavans, An.* 1668.

That this Method, which came out in the Year 1692, under the Name of *Robervall*, is the ſame as that which *Gregory* had publiſhed 24 Years before, Prop. XI. *Math. Univerſ.* as it is plain to any one that views them both, ſo I had granted it without any Heſitation. Indeed I ſaid, that in the Writings of the *French*, wherein it is aſcribed to *Robervall*, it was dreſs'd out with a miſerable and ſhameful Demonſtration. But that it was the ſame with that of *Gregory*, I never once queſtion'd, nor made any Diſpute about it; tho' *Galloyſe* made this the chief Point of the Controverſy, and triumphs as tho' I had yielded him the Victory. But I by no Means grant him, either that it was known before to the *Italians*, or that it was communicated by them to *Gregory*. For how does it appear that it was known to them? Becauſe *Robervall* had communicated it to *Torricellius*. How does this appear? From the Letter of *Torricellius* himſelf. But where is this Letter? *Galloyſe* has it. When was it wrote? About 60 Years ago. Where has it been hid ſo long? Where all wonderful Things are hid, in *Robervall*'s own Treaſury. Whether this Epiſtle is genuine or no, or whether there be any ſuch Thing or no, we muſt not preſume to doubt, ſince there are ſo many credible Witneſſes. But by what Literary Monuments does it appear, that *Torricellius* communicated theſe Inventions to the *Italians?* About this there is ſtill a profound Silence. Or if he had imparted theſe to any, they might by this Time have been quite extinct and unknown, ſince *Torricellius* himſelf had been dead 20 Years before *Gregory* went into *Italy*. Or if they had not been yet out of Memory, *Galloyſe* ſhould tell us, who among the *Italian* Mathematicians imparted theſe Secrets to *Gregory*, which had been intruſted to him by *Torricellius*. Perhaps he will ſay, (for he can take the Liberty of ſaying any Thing) that they were known to many in *Italy*. But would the *Italians* truſt theſe Geometrical Secrets to *Gregory*, a meer Foreigner, which they had concealed from every body for 20 Years? Would he dare, in the Midſt of *Italy*, (for his Book was printed at *Padua*) publiſh Things as his own, which he had but juſt learn'd of the *Italians?* Or if he had been ſo de-void of Shame, could he have done it without being cenſured by the *Italians*, whereas he was rather applauded by them? This I confeſs is beyond my Faith to believe.

---

[g] *Oeuvres des Mathem. per Meſſ. de l'Acad. Roy.*

XXV. *A Paper omitted.*

Logometria, auctore *Rogero Cotes*, Trin. Coll. Cantab. Soc. Aſtron. N. 338. p. 5.
& Ph. Exp. profeſſore *Plumiano*, & R. S. S.

XXVI. *Accounts of Books*, &c. *omitted.*

1. *Lexicon Technicum*, or an Univerſal *Engliſh* Dictionary of Arts and N. 292.
Sciences; explaining not only the Terms of Art, but the Arts them- p. 1699.
ſelves, by *J. Harris*, M. A. and F. R. S. *Folio*, 1704.

2. *Euclidis* quæ ſuperſunt omnia Gr. Lat. ex Recenſione *Davidis Gre-* N. 289.
gorii M. D. Aſtronomiæ profeſſore *Saviliano*, & R. S.S. *Oxon.* 1703. *Folio.* p. 1558.

3. *Apollonii Pergæi* Conicorum Libri octo, & *Sereni Antiſſenſis* de Sec- N. 354.
tione Cylindri & Coni Libri duo. *Fol.* Reg. e Theatro *Oxon.* 1710. p. 732.

The 5th, 6th, *and* 7th *Books of* Apollonius *are here tranſlated out of* Arabic *from a MS. by Dr.* Hally, *in which Language they are only to be found; who has alſo endeavour'd to reſtore the* 8th *Book, which was wholly loſt. The* Greek *Text of* Serenus Antiſſenſis *was never publiſh'd before.*

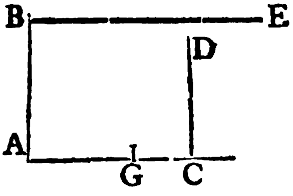
4. De *Locis Solidis* ſecunda Divinatio Geometrica, in quinque Libros in- N. 291.
juria Temporum amiſſos *Ariſtæi* ſenioris Geometræ; Auctore *Vincentio* p. 1607.
Viviani, Magni Ducis *Etruriæ* Mathematico Primario, & Regalis Societatis *Londini* Sodali. Opus *Conicum* in lucem prolatum, An. 1701. *Folio.*

5. *Methodus Incrementorum*, Auctore *Brook Taylor*, LL. D. & R. S. S. N. 345.
An Error *in the* 25th *Propoſition of this Book is here corrected by Dr.* Taylor. p. 339.

This Error does not affect the Reaſoning by which I find the Diſtance of the Center of Percuſſion from the Axis of Rotation; but it is this, that I ſuppoſed the Center of Percuſſion to be in the Plane paſſing thro' the Center of Gravity, and perpendicular to the Axis of Rotation; which is a Miſtake, and is corrected by the following Propoſition.

PROP. PROB.] *To find the Diſtance of the Center of Percuſſion from the Plane paſſing through the Center of Gravity and perpendicular to the Axis of Rotation.*

SOLUTION.] Let this *Figure* be ſuppoſed in the Plane paſſing through the Axis of Rotation, and in which the Center of Percuſſion is ſought.



Let AB be the Axis of Rotation, AGC be the Interſection of this Figure with the Plane paſſing through the Center of Gravity, and perpendicular to the Axis of Rotation; G be the Point whereon a Line, raiſed perpendicular to this Figure, will paſs thro' the Center of Gravity; BE be a Line parallel to AG, wherein is the Center of *Percuſſion*. Then to find the Diſtance AB, let p ſtand for an Element of the Body propoſed, ſtanding per-

pendicularly on any Point D. Draw DC perpendicular to AGC, and AB will be equal to the Sum of all the Quantities $p \times GC \times CD$ taken with their proper Signs, divided by the Body itſelf multiplied into the Diſtance AG.

Having thus found the Diſtance AB, ſuppoſe the Plane of the Figure in *Prop.* 25. to cut the preſent Figure at Right-Angles in the Line BE, and the Center of Percuſſion will be rightly determined by that Propoſition.

N. 342. p. 173. *Vid.* ſupra p. 162.

6. *Commercium Epiſtolicum Collinii & aliorum de Analyſi promota.* Publiſhed by the *Order* of the *Royal Society*, in relation to the Diſpute between Mr. *Leibnitz* and Dr. *John Keill*, about the Right to the Invention of the Method of *Fluxions*, by ſome call'd the *Differential Method.*

This Book conſiſts of Letters, and other Papers, which paſs'd many Years ago between Mr. *Collins*, Sir *Iſaac Newton*, Mr. *Leibnitz*, Dr. *Barrow*, Dr. *Wallis*, Mr. *Oldenburg*, Mr. *J. Gregory*; the Occaſion of their being publiſh'd was this:

The Editors of the *Acta Lipſienſia* for *January* 1705, (in giving an Account of Sir *Iſaac Newton*'s *Treatiſe of* Quadratures) *began* to repreſent, that Mr. *Leibnitz* was the *firſt* Inventor of the *Differential* Method, and that Sir *Iſaac Newton* had ſubſtituted *Fluxions* for *Differences*; Dr. *John Keill* upon this, in a Paper publiſh'd in the *Philoſophical Tranſactions*, (for *September* and *October* 1708. *) aſſerted the Invention to Sir *Iſaac Newton*, appealing to the Letters which Dr. *Wallis* had printed in the Collection of his Works, publiſh'd many Years ſince. Mr. *Leibnitz* upon this complain'd to the *Royal Society* of Dr. *Keill* in 1711; whereupon the *Society* appointed a numerous *Committee* of Gentlemen of *ſeveral Nations* to ſearch old Letters and Papers, and to report their Opinion, which was,

* *Vid.* infra C. IV. S. V.

That from theſe Papers it appears, that Sir *Iſaac Newton* had found the Method of *Fluxions* in or before the Year 1669.

That it does not appear from theſe Papers, that Mr. *Leibnitz* had the Method of *Fluxions* or *Differential* Method before the Year 1677.

Dr. *Wallis* (in the ſecond Volume of his Works publiſh'd) in 1695, aſſerted the Invention to Sir *Iſaac Newton* in theſe Words.—— *Newtoni* Methodus de Fluxionibus — *quam ego deſcripſi ex binis* Newtoni *Literis, aut earum alteris,* Junii 13, & Octob. 24, 1676, *ad* Oldenburgum *datis, cum* Leibnitio *tum communicandis* —— *ubi* Methodum hanc Leibnitio exponit *tum* ante decem Annos *nedum plures* [i. e. ann. 1666 vel 1665.] *ab ipſo excogitatam* —— Several Letters follow'd hereupon, between Mr. *Leibnitz* and Dr. *Wallis*, in which Mr. *Leibnitz* did not deny that Sir *Iſaac Newton* had the Method *Ten Years* before thoſe *Two Letters*; pretended not that he had the Method ſo early; brought no Proof that he had it before the Year 1677; no other Proof beſides the Conceſſion of Sir *Iſaac* that he had it ſo early; affirm'd not that he had it earlier; and commended Sir *Iſaac Newton* for his Candour in this Matter.

When Mr. *Fatio* in 1699 ſuggeſted that Mr. *Leibnitz*, the *Second* Inventor of this Calculus, might borrow ſomething from Sir *Iſaac Newton*,

ton, the *oldeſt* Inventor by many Years, Mr. *Leibnitz*, in his Anſwer in the *Act. Erud.* for *May* 1700, allow'd that Sir *Iſaac* had found the Method apart, and did not deny that Sir *Iſaac* was the oldeſt Inventor by many Years; and aſſerted then no more to himſelf, than that he alſo had found the Method apart, or without the Aſſiſtance of Sir *Iſaac*; nor did he put in his Claim to be the *firſt* Inventor, till after the Death of Dr. *Wallis*, the laſt of the old Men who were acquainted with what had paſs'd between the *Engliſh* and Mr. *Leibnitz* forty Years ago. The Doctor died in *October* 1703, and Mr. *Leibnitz* began not to put his *new* Claim before *January* 1705.

CHAP. II.

OPTICS.

Some of Sir Iſaac Newton's *Experiments of Light and Colours repeated, by Mr.* J. T. Deſaguliers, N. 348. p. 433.

I. THE *Manner of ſeparating the primitive Colours of Light to ſuch a Degree, that if any one of the ſeparated Lights be taken apart, its Colour ſhall be found unchangeable, was not publiſh'd before Sir* Iſaac Newton's *Optics came abroad. For want of knowing how this was to be done, ſome Gentlemen of the* Engliſh College *at* Liege, *and Monſieur* Mariotte *in* France, *and ſome others, took thoſe for primitive Colours which were made by immitting a Beam of the Sun's Light into a dark Room through a ſmall round Hole, and refracting the Beam by a triangular Priſm of Glaſs placed at the Hole. And by trying the Experiment in this Manner, they found that the Colours thus made were capable of Change, and thereupon reported that the Experiment did not ſucceed. And lately the Editor of the* Acta Eruditorum *for* October 1713, pag. 447, *deſired that Sir* Iſ. Newton *would remove this Difficulty.* The Objections (ſays he) which have been made by learned Men, both in *France* and *England*, againſt that Theory of Colours, have been very ſucceſsfully anſwer'd by the moſt perſpicatious *Newton*; as is abundantly manifeſt from the *Engliſh Tranſactions*, N. 84, 85, 88, 96, 97, 121, 123, 128. Whence it is deſired by many, that he would be pleaſed to explain himſelf upon that Difficulty, which was ſtarted by the moſt ingenious Mr. *Mariotte*, in his Treatiſe of *Colours*, p. 207, *&c.* who while he lived was a very indefatigable as well as ſucceſsful Enquirer into the Nature of Things. His Difficulty was this. At the Diſtance of about 25 or 30 Feet he received upon a Paper an entire Ray, let in through a ſmall Hole into a darkned Chamber, which was tranſmitted through a triangular glaſs Priſm; and the violet Colour, which poſſeſs'd a Space of above three Lines, he let paſs through a Slit of two Lines, which he received upon another Priſm placed very obliquely. When this was done, he obſerved ſome Part of this Light to be changed into Red and Yellow. In like Manner he found,

Vid. ſupra, V. I. C. III.

found, that Part of this red Light would be changed into Blew and Violet. Now if this Tranſmutation is admitted, the whole *Newtonian* Theory muſt fall, as is plain from the *Tranſactions* for 1706, p. 60. Now *Mariotte* took the Diſtance of 30 Feet, leſt in a ſmaller Diſtance any one ſhould pretend, that there was not a compleat Separation of the heterogeneous Rays. To us the Experiment of *Mariotte* would appear deciſive, if the whole Blue Light had been changed into ſome other. *Thus far the Editor of the* Acta. *In Anſwer to which it is to be obſerved, that the Red and Yellow which came out of the Violet, and the Blue and Violet which came out of the Red, might proceed from the very bright Light of the Sky next encompaſſing the Sun, and that ſeveral Sorts of Rays which come from ſeveral Parts of the Sun's Body are intermixt in all Parts of the colour'd* Spectrum, *which falls upon a Paper at any Diſtance from the Priſm. In this Manner of Trial, for making the Experiment ſucceed, the Light of the bright Clouds, immediately ſurrounding the Sun, ſhould be intercepted by an opake Skreen placed in the open Air without, at the Diſtance of ten or twenty Foot from the Hole through which the Sun ſhines into the dark Room. And in the Skreen there ſhould be a ſmall Hole for the Sun to ſhine through. The Hole may be either round or oblong, and not above one eighth or one tenth Part of an Inch broad; ſo that the Skreen may intercept not only the bright Light of the Clouds next encompaſſing the Sun's Body, but alſo the greateſt Part of the Sun's Light: For thereby the Colours will become leſs mixed. The Beam of Light which paſſes through this Hole, muſt afterwards paſs thro' the other Hole into the dark Room, and the Priſm muſt be placed parallel to the oblong Hole in the Skreen, and the refracting Angle thereof be ſixty Degrees or above. In this Manner the Experiment may be tried with Succeſs, but the Trial will be leſs troubleſome if it be made in ſuch a Manner as is deſcribed in the fourth Propoſition of the firſt Book of Sir* Iſaac Newton*'s Optics.*

Sir Iſaac Newton *therefore, upon reading what has been cited out of the* Acta Eruditorum, *deſired Mr.* Deſaguliers *to try the Experiment in the Manner deſcribed in the ſaid Propoſition; and he tried it accordingly with Succeſs before ſeveral Gentlemen of the* Royal Society, *and afterwards before Monſieur* Monmort *and others of the* Royal Academy *of* Sciences: *How this and other concomitant Experiments were tried and ſucceeded, is deſcribed as follows.*

Experiment 1.] Having ſew'd together end-wiſe two Pieces of Ribbon four Inches long each, the one Blue and the other Red, whoſe common Breadth was $\frac{1}{4}$ of an Inch; I cauſed it to be held in ſuch Manner, that the Light which fell from the Clouds thro' the Window was ſo reflected, that the Angle made by the Rays of Light, which came in at the Midde of the Window, with the Plane of the Ribbon produced, was equal to the Angle made by a Line drawn from the Ribbon to my Eye, and the ſaid Plane of the Ribbon. My Eye was placed as far behind the Ribbon as the Window was before it, the Diſtance from which to me was about 12 Feet. Then looking thro' a Priſm at the Ribbon, it appear'd broken aſunder in the Place where the Blue and Red Half join'd. If the Priſm was held with the refracting Angle downwards (or laid with one of its Planes flat upon the Noſe) the blue Half of the Ribbon appear'd to be carried down lower than the Red, as at *B*, *R*; but Fig. 36. if the refracting Angle of the Priſm was turn'd upwards, (as when the Priſm has one of its Planes laid flat to the Forehead) then the blue Half of the Ribbon was lifted up, as at ϵ ρ.

The Priſm was of white Glaſs, having every Angle of 60 Degrees; but when inſtead of it, one of a greeniſh Sort of Glaſs, ſuch as Object Glaſſes of Teleſcopes are made of, was uſed, having the refracting Angle which I look'd through of about 48 Degrees; the ſame Phænomenon was more diſtinct, this Glaſs having no Veins, but the Red and Blue were nearer to a ſtreight Line; in ſuch Manner, that if *A* repreſent the Ribbon ſeen through the firſt Priſm, *B* will repreſent the Ribbon ſeen through the ſecond Priſm, *Fig.* 37. If the refracting Angle of the Fig. 37. laſt Priſm had been as great as that of the firſt, the Light being tranſmitted through too great a Body of greeniſh Glaſs, the Phænomenon would not have ſucceeded ſo well.

The blue Ribbon being ſomewhat too pale, and the Red a little dull, I repeated the Experiment with a Skain of Blue, and one of red Worſted join'd together in the Middle as the Ribbons were before; and the Colours of both being very intenſe, the Experiment ſucceeded better with both Priſms. All that were preſent trying the Experiment found it to ſucceed, and that every Circumſtance anſwer'd to the Account given in *Prop.* 1. *Theor.* 1. *Book* 1. of Sir *Iſaac Newton*'s *Optics*, as far as the Directions there given were follow'd. So that it appear'd that the Blue being carried lower than the Red in the firſt Caſe, and lifted higher in the ſecond, was owing to the greater Refraction of the blue Ray: For though each Part of the Ribbon or Worſted reflected all Manner of Rays, yet the Phænomenon was very apparent; as alſo that the blue Ribbon or Worſted reflected the blue Rays more copiouſly than the red Rays, and that the red Ribbon or Worſted reflected the red Rays more than the blue ones, becauſe the Red of the blue Half ſeen through the Priſm was leſs intenſe than that of the red Half, and the Blue or Purple of the red Half ſeen thro' the Priſm was leſs intenſe than that of the blue Half.

N. B. If the Ribbon or Worſted is laid upon any enlightened Body, the Phænomenon will not ſucceed ſo well; the Colours of the Body ſeen through the Priſm mixing with thoſe of the Ribbon or Worſted. Even a black Body will not do, if Light fall upon it: But there muſt be a black Cloth behind, in ſuch Manner, that no Light falling upon it can be reflected ſo as to diſturb the Phænomenon. And if a ſhort-ſighted Perſon looks through the Priſm, a concave Lens between his Eye and the Priſm, will render the Phænomenon more diſtinct than it would otherwiſe be.

Exp. 2.] Some Days after the Sun ſhining, I made two Holes *H*, *h*, Fig. 38. in the Window Shut *S*, *s*, of a darkned Room; through which letting the Sun's Beams paſs, by Means of two Priſms *A B*, (one near each Hole)

Hole) I opened the Rays coming from the Sun into the two coloured *Spectra* α, β, where the following Colours were very diſtinct, *viz.* red, Orange, Yellow, Green, Blue, Purple and Violet. Now the Reaſon of their being more diſtinct than ordinary was, that the Priſms which I made Uſe of, were made of the greeniſh Glaſs mentioned before; which is very free from thoſe Veins by which the Colours are too much thrown into one another, by the beſt white Priſms of the common Sort.

The forementioned colour'd *Spectra* being thrown into the Room, to the Diſtance of about 20 Feet from the Window where the Sun's Light came in, I cauſed a Piece of white Paper ϖ, ¾ Inch broad, and 5 Inches long, to be held within the refracted Rays (at a Diſtance of 10 Feet from the Window) which produced theſe Colours in ſuch Manner, that by turning the Priſms round their Axis, I could make the red Ray of the *Spectrum* made by the one Priſm, fall upon one Half of the Paper, and the purple Ray of the *Spectrum* made by the other Priſm fall upon the other Half; for the *Spectra* were both vertical, the Lines which terminated the long Sides of them towards each other juſt touching, as appears in *Fig.* 38. (Fig. 38.) Then at the Diſtance of 9 Foot, looking through the Priſm *C* at the Paper thus colour'd, the red half appear'd very much ſeparated from the Purple, the one ſeeming lifted up from the other; the Red or Purple appearing the higheſt, according as the refracting Angle of the Priſm was either held upwards or downwards. The Phænomenon is much much diſtinct this Way than any other; for the Paper not only ſeems divided into two, when it is colour'd by a red and a purple Ray, but alſo by a red and blue, *Fig.* 39. (Fig. 39.) by a red and a green Ray, *Fig.* 40, (Fig. 40.) or indeed by any two Colours that are different, how near ſoever their Places in the *Spectra* be to each other. The Halves of the Paper appear, when view'd through the Priſm, to be farther from each other, when the Paper is tinged with ſuch Colours, as are farther from each other in the Series of Colours in the *Spectrum*; and neareſt, though ſtill divided, when neighbouring Colours fall upon the Paper, as Yellow and Green, or a light and a deep Green. But the Paper appears no Way divided, when colour'd with the Red of the two *Spectra*, *Fig.* 41. (Fig. 41.) if thoſe Reds are equally intenſe; and ſo of the other Colours.

Exp. 3.] I held a Lens of about three Foot Radius, at the Diſtance of ſix Feet from the oblong Paper, (on which a red and a purple Ray falling, made it look half red and half purple) and I projected the Image of the ſaid coloured Paper at the Diſtance of about ſix Foot on the other Side of the Lens, on a white Sheet of Paper; where it was obſervable, that when the red Half was diſtinctly painted on the white Paper (which was known by the Edges of the Image being regularly terminated) then the blue Half of the Image was confuſed: But if the white Paper was brought about two Inches nearer to the Lens, the Image of the blue Half became diſtinct, and that of the red Half confuſed.

I tried the Experiment with a Paper coloured half Red and half Blue, the Red with Carmine, and the Blue with Smalt, making the Candle to enlighten the Paper, (the Room being otherwiſe dark) and the Experiment ſucceeded in the ſame Manner. The Experiment thus made, is the ſame that Sir *Iſaac Newton* gives an Account of, *Book* 1. *Part* 1. *Theor.* 1. *of his Optics.* Only it is to be obſerved, that when the oblong Paper is coloured with Red and Blue from the Priſms, the focal Place, where the red Part of the Image is diſtinct, is more diſtant from the Place where the blue Part of the Image is diſtinct, than when the Paper is coloured with the Painter's Powders, and much more vivid.

The 42d Figure ſhews the Projection of the Paper tinged with the Rays; and *Fig.* 43. the Projection of it when painted; where a black Thread is wrapp'd round the red and the blue Part, that the Diſtinctneſs of the Image of the Thread may ſhew when the red or when the blue Part of the Image of the Paper is moſt diſtinct. Fig. 42. Fig. 43.

N. B. When the Candle enlightens the painted Paper, ſet an opaque Body as *B* between the Candle and the Lens; leſt the Image of the Candle being alſo projected, ſhould diſturb the Experiment.

Exp. 4.] Having made an Hole of $\frac{1}{4}$ Inch Diameter in the Window-Shut of the darkened Room, I ſuffer'd a Sun-Beam to come into the Room, which I intercepted with a Priſm at the Diſtance of five Inches from the Hole; and after its Refraction in paſſing through the Priſm, I received it upon a Sheet of white Paper, where it was coloured, making an oblong Image of the Sun or *Spectrum* of about nine Inches in Length, and two in Breadth; which Breadth was nearly equal to the Diameter of the round Image of the Sun received upon a Paper at the ſame Diſtance from the Hole, which here was 18 Foot. Or if the Sun be too high, a Looking-Glaſs being put in the Room of the Priſm, will throw a white round *Spectrum* upon the Paper, which held at the ſaid Diſtance of 18 Foot, will have its Diameter equal to the Breadth of the colour'd *Spectrum.*

The Colours of the *Spectrum* were theſe; red, orange, yellow, green, blue, purple, and violet, though the Violet was ſo faint in this as to be ſcarce perceivable. See *Fig.* 44. Fig. 44.

N. B. The Axis of the Priſm in this, and all the other Experiments hereafter mentioned, muſt be perpendicular to the Ray that falls on it; and the Plane, into which the Ray enters, muſt be held in ſuch a Poſition, that the Angle, which ſuch a Ray makes with that Plane when it enters, may be equal to the Angle made by the middle Line of thoſe Rays which emerge after Refraction, on the other Side of the refracting Angle of the Priſm, with the Plane out of which they emerge. That is $\angle BDG = \angle AEH$.

If the Plane *AC*, on which the Sun-Beam falls, be turned nearer to a Perpendicular to the Sun-Beam than before, the *Spectrum* will be much longer: If it be more inclined to the ſaid Beam, the *Spectrum* will be ſhorter, and in both Caſes leſs diſtinct. See the *Spectrum DE* and the *Spectrum de* where *Hb* repreſents the Hole in the Window-ſhut in each Caſe; *AC*, *ac* the Plane of the Priſm on which the Rays enter; *BC*, *bc* that out of which they emerge; *P*, *p* the perpendicular, and *C*, *c* the refracting Angle. Fig. 45, 46.

Fig. 47. If the Plane *AC* be ſtill more oblique to *HF*, all the Light will be reflected, and there will be no colour'd Image or *Spectrum* made by Refraction at all.

But if it be held ſo as to be more nearly perpendicular to the Sun-Beam than in *Fig.* 47. the whole Beam will indeed enter the Priſm; but meeting with *BC* the lower Surface of the Priſm, or rather the Surface of the Air contiguous to it, ſome of the Light will by the Plane *BC* be reflected to *d e*, paſſing almoſt perpendicularly through *AB*; and the reſt will emerge through *BC*, and by Refraction make the imperfect *Spectrum D E*. See *Fig.* 45. Fig. 45.

Fig. 48. If the Sun-Beam enter *AC* perpendicularly and in the Middle of it the Light will be all reflected as in *Fig.* 48. ſome of it by the Plane *BC* to *R*, and the reſt by the Plane *AB* to *p*. But if the Beam fall nearer to *A*, (ſtill perpendicularly) it will be all reflected by the Plane *AB*; if nearer to *B*, it will be all reflected by the Plane *BC*.

Fig. 44. In order therefore to have the coloured *Spectrum* as it ought to be, Care muſt be taken that the emerging coloured Light may make the ſame Angle with the Plane *BC*, as the immerging Light does with the Plane *AC*; that is, the Angle *AEH* muſt be equal to *BDG*, as was ſaid before, *Fig.* 44. which may alſo be ſeen on the enlightened Duſt in the Air. But the beſt Way is to turn the Priſm on its Axis, and at the ſame Time look at the coloured *Spectrum*, which will riſe and fall and become longer and ſhorter as you turn your Priſm; and between the Aſcent and Deſcent of the Image, will appear ſtationary; there ſtop the Priſm, and the Reflection will be ſuch as is required for all the Experiments hereafter mention'd.

In order to have the Priſm move freely on its Axis, and ſtop any where, I fix'd each End of it into a triangular Collar of Tin, from the End of which came a Wire, which was the Axis of the Priſm produced; and ſo I laid it on two wooden Pillars, with a Notch on the Top to receive the Wires, and fixed it to a ſmall Board juſt broad enough to ſtand faſt. See *Fig.* 49. Fig. 49.

Exp. 5.] I took the Priſm *CD*, and thro' it looked at the coloured *Spectrum R P*, which appeared then round and white as at *S*, juſt as if it had been the Sun's Light received on a Paper from the Hole *H*, and ſeen with the naked Eye. In this Caſe the Priſm *CD* muſt be held *in directum* with *AB*, and the refracting Angles in the two Priſms muſt be equal. This *Spectrum* appearing white but juſt in one Point, is not ſo readily found; but the beſt Way is to look through the ſame Priſm *AB* which makes the *Spectrum*, which may eaſily be done if it be pretty long, and then *R P* will be ſeen white and round, and as at *S*, as if coming directly from *H*. See *Fig.* 50. Fig. 50.

Fig. 51. *Exp.* 6.] I held a broad Lens *L l*, ground to a Radius of 2 ½ Feet, in ſuch Manner that the whole coloured *Spectrum* fell upon it; and after Refraction all the Colours appeared to converge, if received on a Paper at *p p*; but when the Paper was held in the Focus at *F* in the Poſition *πFπ*, the *Spectrum* was round and perfectly white by the Union of all the coloured Rays. If the Paper was held at Π Π, the Colours appeared to diverge from each other, but then the red was uppermoſt, which before uſed to be the loweſt, and ſo on in an inverted Order.

I tried the ſame Experiment with a Lens of one Foot Radius, with one of 9 Inches, and with another of 7, and the Succeſs was the ſame. See *Fig.* 51. where the *RO*, *Y*, *G*, *B*, *B*, *P*, *V*, expreſs the Colours. Fig. 51.

N. B. Care muſt be taken that the very End of the Red, and the Extremity of the Violet, be taken in by the Lens; otherwiſe the *Spectrum* will not be perfectly white with the Glaſs's Focus.

There is no fixed Diſtance of the Priſm from the Lens, but it ought to be brought ſo near the Priſm, that the two Ends of the *Spectrum* may fall nearer the Axis of the Lens than the Edges of the Lens; becauſe there the Refraction is not ſo regular.

Behind the Lens *L*, which made the Colours converge into white at the diſtinct Baſe or Focus *F*, I placed the Lens *l*, which made the white be at *f* the diſtinct Baſe of the two Glaſſes combined; and the Experiment ſucceeded as before. *Fig.* 52. Fig. 52.

When the Paper was held in the Focus of the Lens, ſo as to receive the white Image of the coloured *Spectrum* projected by the Lens; if with a Card I intercepted the red Ray, the white appeared tinged with purple, and if I intercepted the violet or purple Ray, or both, the white appeared tinged with red; and if the red was intercepted at the ſame Time, the *Spectrum* appeared to be a Mixture of yellow, green and blue. If any ſingle Colour was ſuffered to fall upon the Lens, the reſt being intercepted, that Colour would continue the ſame; only it would be more intenſe in the Focus of the Lens.

Exp. 7.] I took a Board (*Fig.* 53.) *q b s* which ſtood reclining on a Prop *t*, having an Hole of a Quarter of an Inch Diameter at *b*, and behind it a Priſm *B* ſupported on two Props as abovementioned, ſo as to turn eaſily about its Axis; and having ſet this Board on the Ground with the Priſm behind it at *B*; by turning the Priſm *AC* about its Axis, I firſt made the red Ray of the coloured *Spectrum* paſs through the Hole *b*, and fall obliquely upon the ſecond Priſm *B*. This Ray after its Refraction in paſſing through the ſecond Priſm, was carried up to the Cieling of the Room at the Place marked *R*; then I made the purple Ray fall upon the Board, and paſs through the Hole *b*, as the red had done before; and after Refraction through the Priſm *B* it was carried up the Ceiling at *P*. And the green Ray being afterwards made to paſs the ſecond Priſm in the ſame Manner, went up to *G*: And ſo of all the intermediate Rays, which were by this ſecond Refraction thrown to the intermediate Places on the Ceiling between *R* and *P*. Fig. 53.

Care is to be taken that the ſecond Priſm be placed oblique to the Rays which come through the Hole *b*; leſt they be reflected, as they would be, if the Board being in the Poſition *QS*, and the ſecond Priſm in the Poſition *LNM*, the Ray from the firſt Priſm be *q b*; for

then

Fig. 54. then it will be reflected upwards to *σ* inſtead of being refracted, *Fig.* 54. Neither muſt the Plane of Immerſion be too oblique, leſt the Incident Ray be reflected downwards by it, as the Ray *R b* is by the Priſm *B* Fig. 55. thrown to *E*, in *Fig.* 55. Several have confeſſed to me that they at firſt uſed to fail in this Experiment, for want of ſetting the ſecond Priſm in a due Inclination.

Though the Colours by the ſecond Refraction on the Ceiling appeared unchanged, when ſeen by the naked Eye, yet if viewed through a Priſm, they afforded new Colours, (except ſome Part of the Red, and ſome Part of the Violet) which was owing to their not being fully ſeparated; for which Reaſon I made the following Experiment, to prove, that if the Colours be well ſeparated, they are truly homogeneal and unchangeable.

N. B. When the Priſms are good, and no Clouds are near the Sun, the Extremity of the Red or Violet will afford unmixed Colours in this Experiment; otherwiſe not.

Exp. 8.] Having made a Hole in the Window-Shut 2 Inches wide, Fig. 56. I applied to it a Tin-plate, which ſliding up and down hid all this Hole in the Wood, and only tranſmitted a ſmall Beam through its own Hole *H*, whoſe Diameter was = $\frac{1}{16}$ Inch. This Beam, by Means of the Looking-Glaſs *L*, placed on the Board of the Window *XW*, I reflected horizontally to the other End of the Room. But to correct the Irregularity of the Reflection of the Looking-Glaſs, I made Uſe of the Frame of Paſte-board *P p*, which had an Hole in it *b* of $\frac{1}{16}$ Inch likewiſe; and placing it at *P p*, I ſuffered ſome of the reflected Beams to paſs through it, ſo as to fall upon the Lens *FE* (convex on both Sides, and ground to a *Radius* of $4\frac{1}{2}$ Feet) at the Diſtance of 9 Feet, ſo that the Image of the Hole *b* was projected to *f* on the other Side of the Glaſs, at the Diſtance of 9 Feet more. Juſt behind the Lens, which by a Screw in the Stand *S* might be raiſed or ſet down, ſo as always to receive the Beam along its Axis, I placed a Priſm *A* (upright on one of its Ends and eaſily moveable about its Axis, by reaſon of its Wire turning freely in an Hole in the ſolid Piece of Wood *T*, which ſtood on another Stand behind the Lens) as near as I could to the Lens *EF*, ſo that the Image of *b* inſtead of being round, white, and projected to *f*, was caſt ſidewiſe on a white Paper ſtretched on a Frame, and appear'd coloured, and 30 or 40 Times its Breadth, as at *MN*. The Colours in this Caſe were very vivid and well ſeparated, only the Violet had ſome pale Light darting from its End, upon Account of ſome Veins in the Priſm *A*, and the Light not coming directly from the Sun, reflected; which ought not to have been, if the Sun had been low enough to have thrown the Rays a good Way into the Room without the Help of a Looking-Glaſs.

To ſhew that the Colours in this *Spectrum* were ſimple and homogeneal Lights, I made the following Experiments.

Exp. 9.] Having made an Hole *b* in the Paper which received the coloured *Spectrum*, I ſuffer'd the red Light to paſs; which being refracted by a ſecond Priſm, fell upon another Paper at *T*, where it appeared ſtill red, whether ſeen with the naked Eye or Priſms of different refracting Angles. To the Eye which ſaw it through the Priſm *V*, it appeared indeed lower as at *t*, but red, round and unchanged. I made the Experiment upon all the Colours, which by this Means appeared to be ſimple and homogeneal. See *Fig*. 57. where the ſame Letters denote the Lens, Priſm and firſt Paper.

Fig. 57.

Through the ſame Lens and Priſm the *Spectrum* was made to fall on a Book; then through the Priſm *F* it appeared unchanged; and the Letters in the Book which croſs'd the *Spectrum* were as diſtinct as when ſeen with the naked Eye. See *Fig*. 58.

Fig. 58.

N. B. The Axis of the Priſm *F* ought to be perpendicular to the long Axis of the *Spectrum s m* thrown on the Book, which will appear as at σ μ; and the Priſm in the Poſition repreſented at *F*, with its flat Side towards the Noſe: For that is the moſt convenient Poſition for looking at the *Spectrum* in theſe Experiments.

I ſuffer'd the purple Ray only to paſs through the Hole *b*, and fall upon a Book at *P*, the Letters of which appear'd at π, and were as diſtinct through the Priſm *Q* as when ſeen with the naked Eye; and I had the ſame Succeſs with all the other Rays. See *Fig*. 59.

Fig. 59.

But if a Sun-beam as *r* comes through the Hole *H* directly upon the Book at *W*, an Eye looking at it through a Priſm at *X* will ſee this Beam at ϒ oblong and coloured, and the Letters on which it falls, confuſed. See *Fig*. 59.

N. B. The Lens ought to be very good, without Veins or Blebs, and ground to no leſs a Radius than I mention'd in the Experiment; though a Radius of a Foot or two longer is not amiſs. The Priſm ought to be of the ſame Glaſs as the Object-Glaſſes of Teleſcopes, the white Glaſs, of which Priſms are uſually made, being commonly full of Veins. And the Room in theſe laſt Experiments ought to be very dark.

A few Days after, having got very good Priſms made for the Purpoſe of the abovementioned Glaſs, I made all the Experiments over again, before ſeveral Members of the *Royal-Society*, with better Succeſs; and had the *Spectrum* very regularly terminated, without any pale Light darting from the Ends of it.

For a further Account of Experiments to this Purpoſe, ſee Sir Iſaac Newton*'s* Optics, *Book* 1. *Part* 1. to which I might have referr'd the Reader altogether; but that I was willing to be particular in mentioning ſuch Things as ought to be avoided in making the Experiments abovementioned; ſome Gentlemen abroad having complained that they had not found the Experiments anſwer, for want of ſufficient Directions in Sir *Iſaac Newton*'s *Optics*; though I had no other Directions than what I found there.

An Experiment *to confirm the Doctrine of* Refrangibility, *by the ſame*, n. 348. p. 448.

II. After the *Experimentum Crucis* made by two Priſms, I ſhould not give the following Experiment, but that it is ſo eaſy to be made, that by it thoſe who want the *Apparatus* (or are unwilling to be at the Pains) to make the *Experimentum Crucis*, may at any Time ſatisfy themſelves of the Truth of the forementioned Doctrine.

Let the Candle A be ſet before the Bar of a Chimney Looking-Glaſs, Fig. 60. ſuch as is repreſented by HH, Fig. 60. which is a Piece of Looking-Glaſs Plate conſiſting of four Planes, ſeen in the Section of it $\alpha f d \beta$, *viz* $d \beta$, which is quick-ſilver'd behind, $f \alpha$ a Plane parallel to it, $f d$ one of the Side-planes bezzell'd towards $d \beta$, or inclined to it in an Angle of about 40 Degrees, (though from 30 to 40 will do, but the greater the Angle the better, if it does not exceed 45°.) $\alpha \beta$ the other Side-plane inclined in the ſame Angle to βd.

The Rays of the Candle which come from A to γ fall obliquely on the Plane $\alpha \beta$; ſo that inſtead of going on to a, they are by Refraction made to incline more towards the Perpendicular pp, namely, to go on in the Line γc, and then are reflected from the Point c on the quick-ſilver'd Surface, in the Direction $c \kappa$, ſo as to make the Angle $\kappa c d = \gamma c \beta$. Now as the Rays which would go to κ, if not refracted, emerge obliquely from the Plane $\alpha \beta$ they leave the Direction $c \kappa$, and decline from the Perpendicular $\pi \pi$, and, being differently refracted, open into four differently colour'd Rays, *viz.* bR a red Ray, bYO a Ray made up of orange and yellow; bGB a Ray made up of green and blue, or a Sea-green, and bP a purple Ray.

If from the Place $E e$ you look full upon the Point b, the *Spectrum* or Image of the Candle at b will appear double; but not mixed; that is, there will appear a Sea-green Spot, and a red Spot, as it were, one upon another, but not ſo as to produce a mixed or intermediate Colour. Then if the right Eye or Eye at E be ſhut, there will appear only a green Spot to the Eye at e; if the Eye at e be ſhut, the Eye at E will ſee only a red Spot.

If you come nearer to b, ſo that the Eyes at e 1, e 2 receive the moſt and the leaſt refrangible Rays, there will be a double *Spectrum*, *viz.* a red and a purple one juſt touching, or upon one another: And the Phænomenon will anſwer as before. *Fig.* 60. Fig. 60.

If keeping both Eyes open, you direct their Axes towards O a Point Fig. 61. nearer than the uſual Place of the compound *Spectrum* S, Fig. 61. which Point is in a Line from the Noſe N to the Point S; or in other Words, if you look full at O, or at the End of your Finger held in O, the red and the blue (or purple Spot) will appear to be divided from each other Fig. 62. after the Manner repreſented at $p\ r$ in *Fig.* 62. where the red will appear to be on the Right-hand, and the blue on the Left.

To make plain what is meant by *ſeeing* the *Spectra* p and r whilſt we look full at O, I beg Leave to explain the Diſtinction between *looking* and *ſeeing*; that I may the better ſhew how this Phænomenon proves that the Senſation of different Colours is cauſed by Rays differently refracted.

Definition 1.] The *Optic Axis* is a Line which, going thro' the Center

of

of the Convexity of all the Coats and Humours of the Eye, falls upon the Middle of the *Retina*, as $a\,a$ or Aa, Fig. 63. Fig. 63.

Def. 2.] To *look* at any Point, is to turn both Eyes towards it in ſuch Manner, that the *Optic Axes* making an Angle at the ſaid Point as a, the Rays from a may have the *Optic Axis* for their Axis, and (by their Convergence upon the *Retina* after Refraction in the *Eye*) may paint the Image of the ſaid Point upon the Middle of the *Retina* of each Eye, where the Optic Axis in each Eye falls.

Def. 3.] To *ſee* without *looking*, is to direct the Optic Axis to ſome other Place than to the Point which is then ſeen; and in ſuch a Caſe, the Image of the Point ſeen will be projected upon a Part of the *Retina* of each Eye, where the Optic Axis does not fall, namely, either nearer to the Noſe N, as in *Fig.* 61. at the Points of the *Retina* mark'd $n\,n$; or farther from the Noſe than the Middle of the *Retina*, as at $o\,o$ in *Fig.* 64. Fig. 61. Fig. 64.

Whatever is *ſeen*, by being *look'd* at with both Eyes, always appears ſingle, by reaſon of the Communication between the Middle of the *Retina* in one Eye, and the Middle of the *Retina* of the other; there being no ſuch Communication between any other Part of the *Retina* in one Eye, and the correſpondent Part of the *Retina* in the other, when theſe correſpondent Parts are equally diſtant from the Noſe.

There is indeed a Communication between the nervous Fibres on the Right-ſide of the Retina *of one Eye, and the nervous Fibres on the Right-ſide of the* Retina *of the other Eye, and ſo of thoſe on the Left; but no ſingle Object can be ſo painted in each Eye, as to have its Image on the right or left Part of one* Retina *that communicates with the right or left Part of the other, of the ſame Bigneſs and at the ſame Time as in the other; becauſe in whatever Poſition the Object is, it muſt be nearer to one Eye than to the other, except it be juſt in a Line from the Noſe betwixt the two Eyes ſtreight forward.*

Hence it is, that if there be two Candles ſet before any one, the firſt at the Diſtance of one Foot, and the ſecond at the Diſtance of two Feet, from the Eyes; he that looks at the ſecond Candle at B will ſee it ſingle, but ſee the firſt Candle, or the Candle A double; one Appearance being in the Line $AD\gamma$, the other in oAE, becauſe it paints itſelf upon oo in the *Retina* of each Eye; which Points are not the middle Points, but farther from the Noſe than the Middles $m\,m$.

So if B be the firſt Candle, and C the ſecond, he that looks at B will ſee C double, becauſe it is painted in the *Retina* at the Points $n\,n$ nearer the Noſe than $m\,m$; and ſo will appear to be in the ſame Poſition as $p\,r$, in *Fig.* 62. Fig. 62.

If $\gamma\,\rho$ be two Candles ſo diſpoſed, that by the Interpoſition of a perforated Board FF, γ can paint itſelf only in the Eye R, and ρ in the Eye L. Fig. 65. Upon making the Optic Axes meet at B, and to tend towards ρ and γ, ρ and γ will each paint an Image on the Middle of the *Retina* of each Eye, by croſſing their Rays at B: And thus the two Candles will appear to be but one, or rather to be in one Place, upon the Account of the Communication of the Middle of each *Retina*. But if inſtead of the Candles, ϱ be a Piece of red Silk, and γ a Piece of green Silk, the ſame Poſition of the Eyes will make an Image at *B*, appearing like a red and green Spot together, without a Mixture of the Colours. If ϱ be a red hot Iron, and γ a Candle of Sulphur, the Phænomenon will be more diſtinct. If the Optic Axes be turned directly towards γ and ϱ, as if there was no Board *FF* in the Way, there will appear two Holes in the Board, the one having the red hot Iron in it, the other the Candle.

Fig. 60. Now if, of the refracted Rays of the Candle in the firſt Caſe, thoſe which diverge from each other, ſo as to fall into each Eye, cauſe the ſame Senſations reſpectively, as the Rays which come from a red hot Iron, and thoſe which come from a blue Candle; it is evident that the Candle in the firſt Caſe affords red-making and blue-making Rays after Refraction, and that thoſe Rays are differently refrangible; the red *bR* the leaſt refrangible, as declining leſs from the Perpendicular [illegible]; and the purple as *bP*, declining moſt from the ſaid Perpendicular.

Fig. 60.

The ſame will (*cæteris paribus*) be found true in the intermediate Rays, and to be certain that the Experiment is as I have related it, the Planes *af* and *fd* of the Bar may be covered with Paper.

An Univerſal Sphærico-Catoptric *Theorem, by Mr.* H. Ditton, n. 295. p. 1810.

III. The Finding of the Foci, both in Dioptrics and Catoptrics, eaſily follows from the Calculation for the Curves called Cauſtics. For nothing more is required, than that the Locus may be known in which the Radius (perpendicular to the Curve either refracting or reflecting) is a Tangent to the Diacauſtic or Catacauſtic Curve. Concerning which Method Mr. *Hayes*'s Book of Fluxions lately publiſhed may be conſulted. We ſhall undertake the Matter upon other Principles, as far as Catoptrics are concerned.

Fig. 66. Let *DEF* be a Portion of a concave Spherical Speculum, whoſe Center is *B*, Semidiameter *BE* or *BD*; alſo let *A* be a radiating Point placed in the Axis, from whence proceeds the Ray *AD*, which at the Point *D* is reflected in *DC*. Now the Diſtance of the Focus *C*, from the Vertex of the Speculum *E* is to be inveſtigated.

It is to be obſerved, that we ſuppoſe the Point *D* to be very near *E*. For the remoter Rays go beſide the Eye, which we place in the Axis *AE*, nor do they contribute any Thing to Viſion. And becauſe of the indefinitely ſmall Arch *DE*, the Angles *DAB*, *ADB*, and alſo their Sum *DBC*, are the ſmalleſt poſſible, and therefore will have the ſame ratio to one another as their oppoſite Sides. By making this the Principle of his Reaſoning, Dr. *Halley*, Profeſſor of Geometry at *Oxford*, arrived at his Dioptrical Theorem.

Theſe Things being premiſed, let $AB = b$, $BD = BE = r$, $BC = z$, $CE = r - z$, which for Brevity we will call f. The Quantities b and r are known; for the Semidiameter of the Speculum, and the Diſtance of the lucid Point from the Vertex are given; but z and f are unknown and required. Now in the Triangle *DAB*, it will be Ang. $DAB \,.\, ADB :: r \,.\, b$. Alſo in the Triangle DBC, 'tis Ang. $BDC = ADB$ from the Nature of Reflection; and Ang. $DBC = DAB + ADB$, by *El. Eucl.* Therefore ſince Ang. DBC is as $r + b$, and Ang. BDC as b; it will be alſo Ang. $DBC \,.\, BDC :: r + b \,.\, b$. And then it follows from the Principle above-mentioned, $DC \,.\, BC :: r + b \,.\, b$. But becauſe the Point D is very near the Point E, DC will be eſtimated as equal to CE; and therefore it will be $CE \,.\, BC :: r + b \,.\, b$, that is, $f \,.\, z :: r + b \,.\, b$. And by comparing the Sums of the Antecedents and Conſequents to the Antecedents, $f + z \,.\, f :: r + 2b \,.\, r + b$. But $f + z = r$, therefore $r \,.\, f :: r + 2b \,.\, r + b$, whence $f = \frac{rr + br}{r + 2b}$. *Q. E. I.*

If we make $r + b = AE = d$, the Theorem will be abbreviated thus $f = \frac{rd}{2d - r}$. But in either Caſe the Theorem will ſerve for finding the Focus, whatever be the Form of the Speculum, or the Condition of the Rays.

Corol. 1. It will be $zd = df - rf$, or $AE \times BC = AB \times CE$, or which is the ſame Thing, the Line AE is harmonically divided in the Points A, B, C, E. For the foregoing Equality of Rectangles is the Property of a Line divided in harmonical Proportion. This appears to be true, becauſe $f = \frac{dr}{2d - r}$, and $z = r - f = r - \frac{dr}{2d - r}$; whence by ſubſtituting theſe Values, the Equation becomes plane. So that in every ſpherical Speculum, the Lines DA, DB, DC, DE, are Harmonicals; and the radiating Point, the Center, the Focus, and the Vertex, are Points that conſtitute an harmonical Diviſion.

Corol. 2. Firſt, if you make $d > r$, then by the Calculation f, or $\frac{rd}{2d - r}$, is alwas greater than $\frac{1}{2} r$. That is, if the Diſtance of the radiating Point is greater than the Semidiameter of the Speculum, the Diſtance of the Focus will always be greater than a Quarter of the Diameter.

Alſo it will always be $\frac{rd}{2d - r} < r$. That is, the Diſtance of the Focus will always be leſs than the Semidiameter of the Speculum.

Secondly, If you make $d = r$, it will be $f = \frac{rd}{2d - r} = r$. That is, if the radiating Point be placed in the Center of the Speculum, its Image will there be united with it.

Thirdly, if you put $d < r$, then the Expreſſion of f will either be poſitive, or negative, or infinite, according as the Quantity $2d$ is either greater or leſs than the Quantity r, or equal to it.

If $2d > r$, that is, if $d > \frac{1}{2}r$, then the radiating Point and the Focus lie on the ſame Side of the Speculum.

If $2d < r$, or $d < \frac{1}{2}r$, then the Image will be in the Axis of the Speculum produced beyond the Vertex.

If $2d = r$, or $d = \frac{1}{2}r$, the Image is at an infinite Diſtance, or the reflected Ray becomes parallel to the Axis.

Corol. 3. It may be determin'd very readily by Means of this Calculus, how the Motion of the Image correſponds with the Motion of the radiating Object in reſpect of the Speculum. Let the Diſtance of the Image from the Speculum be as before $\frac{dr}{2d-r}$, when the Diſtance of the Object is d. Now let the Diſtance of the Object be any how changed, and of d let it become nd, making n to ſtand for any Number Integer or Fraction. Then inſtead of the former Equation $f = \frac{dr}{2d-r}$, we ſhall have another Equation to a new Focus $F = \frac{ndr}{2nd-r}$. And if n is ſuppoſed to ſtand for an integer Number, this ſecond Diſtance of the Object will be greater than the firſt; but if n be a Fraction, then it will be leſs than the firſt.

Theſe Things ſuppoſed, if $d > r$, and n be an Integer, it will be $F < f$, that is, it will be $\frac{ndr}{2nd-r} < \frac{dr}{2d-r}$, or $2nddr - ndrr < 2nddr - drr$ as is manifeſt. That is, in a concave Speculum if the Diſtance of the Object be greater than the Semidiameter, then the Object withdrawing from the Speculum, the Image will approach nearer the Speculum. Again, let n denote a Fraction, and then it will be found, that $2nddr - ndrr > 2nddr - drr$, or $F > f$. That is, as the Object approaches nearer the Speculum, the Image at the ſame Time will withdraw farther from it.

Now let it be ſuppoſed that $d < \frac{1}{2}r$; and let nd be any other Diſtance of the Object, which is always leſs than $\frac{1}{2}r$. Then will $2nddr - ndrr$ and $2nddr - drr$ be negative Quantities, or $ndrr - 2nddr$ and $drr - 2nddr$ will be poſitive Quantities. And if n be an integer Number, then will $ndrr - 2nddr > drr - 2nddr$, or $F > f$. But if n be a Fraction, then will $ndrr - 2nddr < drr - 2nddr$, or $F < f$. That is, if in the Concave Speculum the Diſtance of the Object be leſs than a fourth Part of the Diameter of the Speculum, then the Object withdrawing from the Speculum, the Image will withdraw alſo. Or if the object approaches towards the Speculum, the Image will alſo approach towards it.

Now all theſe Concluſions which we have deduced, by tracing the Footſteps of the Calculation, are included in one *Scholium*, which Dr. *Gregory*, Profeſſor of Aſtronomy in the Univerſity of *Oxford*, has delivered in his Catoptricks.

Corol. 4. In the Equation $f=\frac{dr}{2d-r}$, if d be ſuppoſed infinite, it will be $f=\frac{1}{2}r$, which is a Rule for parallel Rays, or for a radiading Object placed at an infinite Diſtance. The ſame Thing will follow, if b be made infinite in the Equation $f=\frac{rr+rb}{r+2b}$.

Corol. 5. In the Equation $\frac{dr}{2d-r}=f$, the negative Sign of the Quantity r being made poſitive, it will be $f=\frac{dr}{2d+r}$; or in the Equation $f=\frac{rr+br}{r+2b}$, changing the poſitive Sign into a negative, it will be $f=\frac{rb-rr}{2b-r}$; which gives a Rule for a Speculum which is convex towards the radiating Object. This Change of the Sign is very plain; for as in the concave Speculum it is $d=r+b$, ſo in the convex it will be $d=b-r$.

Corol. 6. In a convex Speculum, (thoſe Things remaining which we have taken Notice of at *Corol.* 3. about a concave Speculum) it will appear, that if n be an integer Number it will be $2rndd+ndrr > 2rndd+drr$; and if n is a Fraction it will be $2rndd+ndrr < 2rndd+drr$. That is, if the Object withdraws from the Speculum, or if it approaches towards it, the Image in like Manner will recede or approach.

Alſo it appears in a convex Speculum, that if the Object withdraws to an immenſe Diſtance, yet that its Image will not recede from the Vertex beyond a fourth Part of the Diameter, but will there ſtop in the middle Point between the Center and the Vertex. For ſuppoſing d or b to be infinite, it will be $f=\frac{dr}{2d}$ or $\frac{br}{2b}$, in each Caſe $f=\frac{1}{2}r$.

To theſe may alſo be join'd the Solution of a Catoptrical Problem. To find ſuch a Poſition of the radiating Point in reſpect of a given Speculum, that the radiating Object may have a given Ratio to its Image made by the Speculum. Let the given Ratio be that of r to q, and by the Symbol O let the Magnitude of the Object be denoted, let I be the Image, d the Diſtance of the Object, and f of the Image from the *Speculum*. Now as Dr. *Gregory* has demonſtrated, it will be $O\,.\,I :: d\,.\,f$. That is, the

Object and the Image are directly proportional to their Diſtances from the Vertex of the Speculum. And becauſe it is required that it may be $O . I :: r . q$; it muſt alſo be $d . f :: r . q$; or inſtead of f taking its Value, $d . \frac{dr}{2d-r} :: r . q$, whence $2dq - rq = rr$, and $d = \frac{rr+rq}{2q}$. Now becauſe $dr = \frac{r^3+r^2q}{2q}$, and $2d - r = \frac{rr}{q}$; it will be f or $\frac{dr}{2d-q}$ $= \frac{r^3+r^2q}{2q} \div \frac{r^2}{q} = \frac{r^3+r^2q}{2q} \times \frac{q}{r^2} = \frac{r+q}{2}$, which is the Diſtance of f or of the Image from the Speculum, agreeing to the Diſtance of the Object. Therefore if the Object be ſet at the Diſtance $\frac{rr+rq}{2q}$, its Image made at the Diſtance $\frac{r+q}{2}$ being compared to it, will have the Ratio of q to r. Or it will be, $O . I :: r . q$. For it is $O . I :: d . f ::$ $\frac{rr+rq}{2q} . \frac{r+q}{2} :: r . q$.

Here we have conſidered the radiating Object and the Image as if they were Lines; but if we conſider them as Surfaces then it will be $O . I :: dd . ff :: r . q$; ſo that then we ſhall come to this Equation $4\,dd - 4\,q\,d\,r = r^3 - q\,r^2$; from whence the Value of d may be found very eaſily by the common Methods.

A Way for Myopes *to uſe* Teleſcopes *without Eye-Glaſſes, &c. communicated by Dr.* J. T. Deſaguliers, n. 361. p. 1017.

IV. *Myopes* may uſe *Teleſcopes* without Eye-Glaſſes, an Object-Glaſs alone becoming as uſeful to them, and ſometimes more than a Combination of Glaſſes.

Lemma 1.] What is required of a Teleſcope is to give large and diſtinct Viſion; that is, to make the Object (as in *Galileo*'s Teleſcope) or its Image (as in the Teleſcopes made up of convex *Lentes*), appear under a great Angle, and to have all the Rays of thoſe Pencils that enter the Eye, meet in a Point upon the *Retina* of the Eye, on their reſpective Axes.

Fig. 67. The 67th Figure repreſents the Combination of two convex *Lentes* for the aſtronomical or inverting Teleſcope; where the abovementioned Requiſites are obtain'd. *A B* is the Object ſuppoſed at a vaſt Diſtance from the objective *Lens L L*, ſo that Rays coming from the Extremity *A* of the Object, will fall upon the *Lens LL*, in the ſame Manner as if they were parallel to their Axis *A X*; and after paſſing the Glaſs unite at *a*, where they project the Image of the Point *A*, from whence diverging, they fall on the Eye-Glaſs *l l*, and having paſſed through it, go on parallel to each other, and enter the *Cornea* of a common Eye *E*, which unites thoſe parallel Rays upon its *Retina R R R* at *α*, where the Image of *a* is projected; The ſame may be ſaid of the Rays that come from *B*, and after their ſeveral Refractions thro' the two Glaſſes and the Coats and Humours

the Eye, meet upon the *Retina* at *b*, where they project the diſtinct Image of the Point *b*. The Rays that come from all the Points of the Object *A B*, being affected after the ſame Manner, give a diſtinct Image of thoſe Points upon the *Retina*, and therefore the Object does appear diſtinct.

The Object will alſo appear magnified in the ſame Proportion as the Angle *l C l* = to *b M a* (under which its Image is ſeen) is greater than the Angle *A C B* under which the Object *A B* would be ſeen by the naked Eye; as is more at large demonſtrated by dioptrical Writers.

Lemma 2.] If parallel Rays fall upon the *Cornea* of a *Myops*, or ſhort-ſighted Perſon, they will unite in the Eye before they come to the *Retina*, the farther from it, the more convex the Eye is; but if the Rays which fall upon the *Cornea*, diverge in Proportion to the too great Convexity of the Eye, as from *D*, ſuch Rays will be ſo refracted by the Coats and Humours of the Eye, as to meet in one Point upon the *Retina* *R R*, where I have in the Scheme neglected the Refraction of the Rays paſſing out of the *chryſtalline* *K* into the *vitreous* Humour V, as I do in the other Caſes.

Fig. 68, 69.

This *Lemma* is alſo demonſtrated by dioptrical Writers.

Lemma 3.] If two Pencils of Rays (in each whereof all the Rays are parallel to the Axis, as *a C*) fall upon different Parts of the *Cornea*, at the greateſt Diſtance from one another that can be allow'd for thoſe Rays to enter the Pupil *P P*, their *Axes* will, after entring the *aqueous* Humour, converge, and meet either in the vitreous or chryſtalline Humour, according to the Convexity of the *Cornea* through which they paſſed, and diverge again before they come to the *Retina*; the Rays of each Pencil converging upon their reſpective Axes, to the Place where the ſaid Axes croſs one another.

Fig. 70.

Demonſtration.] The Axes *a C a*, *a C a*, falling obliquely upon the *Cornea* at C C, and entring from *Air* into the *aqueous* Humour, will be refracted towards the Perpendicular to *K*, where ſtriking more directly upon the *chryſtalline*, they will go on to *a*, *a*, upon the *Retina* *R R R R*, decuſſating at *V* within the *vitreous* Humour. The other Rays *r*, *r*; *ρ*, *ρ*, after their Refraction in the *aqueous* Humour, fall more obliquely on the *chryſtalline*, and therefore are refracted again ſo as to meet at *V*, where the Axes alſo meet, and thence go on to the *Retina* *R R R R*.

Fig. 70.

Lemma 4.] But if the Axes of the abovementioned Pencils are parallel, the Rays that accompany them diverging from a Point ſo near the Eye, that the Divergence may be proportionable to the too great Convexity of the Eye; then only the Axes will meet in the Eye before they come to the *Retina* (by *Lemma* 3.) but the other Rays will not unite upon their reſpective Axes, till they come to the *Retina*, (by *Lemma* 2.)

Prop.] I ſuppoſe the Eye of the *Myops* ſo convex that he can ſee no farther than a common Eye, with the Eye-Glaſs of a Teleſcope before it: Then the Eye of the *Myops* being in the Place of the Eye-Glaſs, will receive the Rays diverging from the ſeveral Points of the Image (projected by the Object-Glaſs in its *Focus*,) in ſuch Manner, that they will, after the ſeveral Refractions, meet in reſpective Points on the *Retina*; and the Axes of the Pencils, which come from the Extremities of the Object, will, in the Eye, make the Angle *B V A* = to *b c a*, under which the Image *a b* is ſeen, by *Lemma* 4. The *Cornea* and *aqueous* Humours here ſupply the Place of the Eye-Glaſs, and the *chryſtalline* and *vitreous* Humours that of a common Eye. In the Figure *R* is the *Retina*, *V* the *vitreous* Humour, and *K K* the *chryſtalline* Humour; and the Image *b a* is ſuppoſed to be brought down from the 67th Figure, which repreſents the *Aſtronomick Teleſcope*; the too great Convexity of the Eye here being in the Place of an Eye-Glaſs.

Fig. 71.

An Objection may be made to this, *viz.* that *P P* the Pupil of the Eye being ſmall, will take in but a very little Image, or a ſmall Part of the Object: But then if the Eye be moved ſucceſſively, to all the Parts of the Space where the Eye-Glaſs was, it can take any Part of the Object; and if the Object-Glaſs be large, which may more eaſily be made than a large Eye-Glaſs, and the Tube a Foot wide or wider, as much may ſucceſſively be taken in, as if an Eye-Glaſs might be had of a Foot Diameter. A little Practice may make any *Myops* ſo ready, as to keep an Object when once found, though the Place where he ſtands be ſhaken. It would not be amiſs to hold a *Lens* in one's Hand (for an Eye-Glaſs) to find the Object at firſt, till Cuſtom has made it eaſy without it: When once the Object is found, it may be eaſily kept.

An Eye more ſhort-ſighted than I have ſuppoſed, will perform the Office of a more convex Eye-Glaſs, being brought nearer to the diſtinct Baſe of the Object-Glaſs; and an Eye leſs convex, the Office of a leſs convex Eye-Glaſs: But with this Difference, that the more convex the Eye is, the eaſier may any Part of the Object be found, and the larger and more lucid it will appear.

I have ſeen *Saturn*'s Ring very plain with an Object-Glaſs of little more than ſix Foot *Radius*, without an Eye-Glaſs.

I have alſo found out a Way for the *Presbitæ* to make uſe of an Object-Glaſs, by placing their Eye nearer the Lens than its Focus, by ſo much as their Eye is flatter than a common Eye, ſo as to make (as it were) the Teleſcope of *Galileo*; the flat Eye ſerving as a common Eye armed with a concave Lens. I have ſo fixed the Teleſcope as to make a *Presbita* read at a great Diſtance a ſmall Print. The Truth of this may be eaſily demonſtrated, if it be required.

If this Experiment be made at Sea with a very large Tube, big enough to put in the Head and move it about, and the Object-Glaſs be alſo large, it may not perhaps be difficult to obſerve the Eclipſes of the *Satellites* of *Jupiter*, which I would recommend to the Conſideration of thoſe that would try for the Longitude by ſuch-like Obſervations.

Experiments upon Metals, with the D. of Orleans's *Burning-glaſs, by Mr.* Geoffroy, n. 322. p. 374.

V. The Burning-Glaſs is three Foot in Diameter; it collects the Rays of the Sun at ten Foot Diſtance, where it forms a Focus of about three Inches over, which is again contracted by means of another Glaſs-

Lens to an Inch Diameter, and conſequently is rendered three Times as ſtrong.

I ſhall only relate here what I have obſerved upon the four Imperfect Metals, *viz.* Iron, Copper, Tin and Lead: I ſhall ſay nothing at preſent of Gold or Silver; becauſe as their Analyſis ſeems to me much more difficult than of the other Metals, I ſhall forbear Inquiries upon them, till I have examined as far as poſſible into the Nature and Compoſition of the former.

What was a great Hindrance to me in making theſe Experiments in the Focus of the Glaſs, was the Difficulty I had to find any Matter capable of holding the Metals in Fuſion.

Charcoal, which is commonly made Uſe of, is indeed a very proper Subſtance; but it is impoſſible with it to vitrify any one of the Metals: The Particles of the Metal, when held any long Time in Fuſion in the Focus of the Glaſs, diſſipate and fly away in Fume or ſmall Particles; and as long as any Part remains, that little that does remain, is always metallick, until the whole be quite evaporated.

The Reaſon of which I take to be this. Charcoal is a Subſtance deeply impregnated with oily or ſulphurous Parts (if I may ſo call them.) The firſt Effect that Fire has upon Metals is to ſeparate the ſulphurous Parts: Now, if in Proportion as the Sulphur is ſeparated from the Metal, the Body that ſupports the Metals furniſhes it anew with other ſulphureous Parts, the other Principles will never ſeparate, and the Metal will always remain Metal. And nothing but the greateſt Degree of Fire is able to raiſe and ſeparate the Sulphur, and that but by little and little, and in very ſmall Particles.

I had then Recourſe to another Matter, that could not any ways be ſuſpected of containing any oily Parts. *Tſchirnhaus* (to whom we are obliged for making of theſe large Glaſſes, and the firſt Experiments that have been made with them) ſays, he has vitrified Metals by holding them in *China*-Ware. It is true, this ſucceeds pretty well, provided the Pieces be very thick, and the Glazing taken off: But the Difficulty I had to find a ſufficient Quantity of thick and proper *China*-Ware to make all theſe Experiments, forced me to have Recourſe to more common Subjects, as well as ſuch, if poſſible, as were leſs capable of melting.

Of all the different Sorts of Matter that I made Trial of, what ſeemed beſt were the common Coppels and Plates of grey Fire-ſtone. The Coppels hold the Metal a long Time in Fuſion in the Focus of the Glaſs without melting; excepting Lead, which eaſily runs through them as ſoon as it vitrifies, and helps to diſſolve them. The Plates of Fire-ſtone bear the Heat of the Focus much longer than any other Matter; but great Care is to be taken in heating them without breaking, 'till they become red hot, and when they are hot the leaſt cold Air makes them melt. Nevertheleſs this is the only Subſtance that I have uſed with moſt Succeſs, to hold Metals a long Time in Fuſion, though with the greateſt Caution that was poſſible, to avoid the Inconveniencies aforementioned.

Another Thing that has hinder'd me from carrying on theſe Inquiries upon Metals ſo far as I could have wiſhed, has been the few clear Days we have had for theſe two Years paſt; for the greateſt Part of theſe Experiments require a bright, ſtrong, and conſtant Sun, to keep the Matter a long Time in perfect Fuſion: And I have ſcarce had, for this laſt Year, above three or four ſuch Days as I could wiſh for; the Sky having been almoſt every Day covered with Clouds about Noon, which is the Time of the Day fit for theſe Experiments.

On Iron. I placed in the Focus of the Burning-Glaſs a Piece of forged Iron of about a Drachm Weight: It turned red hot, and its Surface was cover'd with a black Matter like Pitch or Tar. If one withdraws the Iron out of the Focus in this State, this Matter fixes itſelf on the Surface of the Metal, and there forms a ſmall Skin, or a very fine blackiſh Scale, which is commonly very eaſily ſeparated by ſtriking upon it; and that Part of the Iron that was covered with this Scale appeared blacker than ordinary. This Scale is ſome of the ſulphureous Part of the Iron that riſes to the Surface of the Metal when it is ready to melt, and there remains for ſome Time before it exhales. It is plainly this ſulphureous Part that riſes upon Iron and poliſhed Steel when heated, and gives them all thoſe different Colours, from a Yellow to a Violet, Water-colour, or Black.

If one continues to hold this Piece of Iron on the Charcoal, it intirely melts; and at the ſame Time caſts forth very bright Sparks in a great Quantity, ſometimes to above a Foot Diſtance from the Coal.

If one ſaves what flies off during this Sparkling, by holding a Sheet of Paper under the Coal; we find that they are ſo many very ſmall Globules of Iron, and the greateſt Part of them hollow.

All the Iron that is held in Fuſion upon the Coal, flies away in Sparkles after this Manner, till none remains. Sometimes the Metal leaves off ſparkling, when the Coal is in part conſumed, and covered with a Bed of Cinders, upon which lies the melted Iron. For as the ſparkling of the Iron ſeems to me to proceed from nothing but the oily Parts of the Coal acting upon thoſe of the Metal, the Cinders hinder this Oil from paſſing from the Coal to the Iron, ſo that it remains quietly in Fuſion. But if through any Shake, or the like Accident, the Cinders are ſo removed, that the Iron comes to touch immediately the Coal, it will begin to ſparkle afreſh. Sometimes the Heat, that keeps in Fuſion the Metal, vitrifies alſo the Cinders; and this vitrified Matter mixing with the Metal makes a conſiderable Ebullition. If one at this Inſtant withdraws the Metal out of the Focus, it appears half vitrified, or reduced to a blackiſh friable Maſs. Other Times this vitrified Matter ſwims on the Surface of the Metal, and there forms itſelf into Drops, that are ſometimes clear and tranſparent, and other Times opaque, according as it is more or leſs mixed with the Metal.

Furthermore, if after having let the melted Iron cool upon the Coal, one expoſes it again to the Focus of the Glaſs upon the Stone, it ſparkles afreſh till it is all conſumed; which common Iron will not do, that has not been expoſed to the Heat of the Focus upon Charcoal. This Sparkling probably proceeds from the ſudden Rarefaction of the oily Parts of the Coal, with which the Pores of the Iron are ſo plentifully ſaturated; or perhaps it may be cauſed by the Salts of the Iron acting on the Oil of the Coal.

I expoſed to the Focus, upon a Stone-ſlate, Iron and Steel; they grew red hot, and melted without crackling or caſting off any Sparks; they ſmoaked very conſiderably, and the melted Metal turned by little and little like an Oil. After having withdrawn this melted Matter out of the Focus, it fixed in a Regulus-like, friable Maſs, and appear'd ſometimes lightly ſtriated, or ſhot into ſharp Points like Needles. Tho' this Matter does not appear at all tranſparent, yet we may look on it as the Beginning of Vitrification, or a middle State between Metal and Glaſs; for it would vitrify in the End like other Metals, if one could hold it a ſufficient Time in the Focus without melting or mixing with what ſuſtains it: But continuing it long in the Focus, the extreme Heat of the Sun, that is neceſſary to keep it in perfect Fuſion, melts likewiſe the Stone or Coppel that contains it, the Reſult of which Mixture is a brown or greyiſh Sort of Ennamel.

We may then take this Regulus Maſs to be a half vitrified Iron, by reaſon it is deprived of a great Part of its Sulphur. If one adds to this Maſs a Sulphur like that which was taken from it, from being friable it turns very hard and malleable; and the Dulneſs it had before, changes to the Brightneſs of a Metal. This is what I have experienced in expoſing again this Matter to the Focus upon Charcoal: It melts, and ſo continues a conſiderable Time in Fuſion without ſparkling, but at laſt it ſparkles with the ſame Briſkneſs as Iron itſelf; and when withdrawn from the Focus, appears nothing different from melted Iron.

It appears from theſe Experiments, that Iron contains a Sulphur or oily Subſtance, that renders it bright, malleable, and eaſy to melt.

That this Sulphur is raiſed by the Fire of the Sun, when the Metal is for ſome Time held in Fuſion in the Focus of the Glaſs.

That this ſame Sulphur may be raiſed by the Flame of common Fire, which tho' not ſtrong enough to melt the Iron, yet is able to reduce it to an Eſchar or Sort of Ruſt.

That Iron deprived of this ſulphureous Part, melts into a Regulus, or brittle and friable Maſs, in Colour much like Antimony.

That if one can hold a ſufficient Quantity of this Matter long enough in the Focus by itſelf, without melting or mixing with the Body that contains it, it perfectly vitrifies.

That this Glaſs or metallick Regulus, with the Help of a little Oil, returns to its former State of a Metal.

That it reaſſumes this metallick Form upon Charcoal, by drawing thence this oily Subſtance.

That, in ſhort, this oily Part contained in the Coal, is little different from the Sulphur of Iron. Nevertheleſs we muſt imagine it to differ in ſome Particulars; in that melted Iron, that has been ſaturated with it, crackles and ſparkles very much when melted again upon the Stone or Coppel.

Iron being the only Metal in which I have obſerved this Sparkling, I take it to be a Property peculiar only to Iron, and not to any other Metal. Perhaps we may attribute it to the vitriolick Salt that this Metal ſo plentifully abounds with, which is very greedy of Sulphurs.

To this ſame Greedineſs alſo, with which the vitriolick Salt of Iron abſorbs the oily Part of the Coal, we may attribute the Eaſineſs with which Iron conſumes the Coal; for there is no other Metal that ſo ſoon waſtes the Coal in the Focus of the Glaſs, as Iron does.

Another Obſervation is, that it is the only one of the four imperfect Metals, on which vitrified Drops ariſe, while it is in Fuſion upon the Coal: The Reaſon of which I have not yet been able to diſcover.

On Copper. Copper expoſed to the Focus of the Burning-Glaſs, at firſt turns white on its Surface, and afterwards grows black, and is covered with a Kind of Skin, or black, furrowed, and uneven Scales, till at laſt it quite melts.

I have withdrawn this Metal out of the Focus, as ſoon as this white Colour has appear'd, and after it has been cold, found nothing extraordinary on its Surface, which has again by little and little recover'd very near the ſame Colour as it had before.

I have not been able to diſcover from whence this white Colour proceeds, unleſs we may attribute it to ſome volatile arſenical Salt contained in the Copper, and driven by Extremity of Heat to the Surface of the Metal; or whether it purely proceeds from the Alteration that is made in the groſſer Parts of the Surface of the Metal when it begins to melt. The black Colour that Copper afterwards takes, ſeems to be cauſed by the ſulphureous Matter that melts firſt in this Metal as well as Iron, and is raiſed to its Surface by the extreme Heat.

I placed a Piece of Copper in the Focus upon Charcoal: It melted, and emitted a very thin Fume, and by little and little diminiſhed till it was all evaporated.

I put a Piece of red Copper on a Coppel into the Focus of the Glaſs: It melted, and ſent forth ſome thin Fumes; and after it had been ſome Time in Fuſion, it turned liquid like an Oil. I withdrew this melted Matter, and as it grew cold, it fixed into a Regulus of a reddiſh brown Colour, which was hard, brittle, and not ductile under the Hammer. If one breaks it, it turns into a red Powder like Cinnabar of Antimony; and when viewed with a Microſcope, appears ſo many little, red, tranſparent Grains, like ſmall Rubies; inſomuch that one would readily take this Regulus to be a deep coloured red Glaſs.

I endeavoured to make this vitrified Copper ſpread abroad in melting, by mixing it with common white Glaſs; for which End I powder'd ſome of this vitrified Copper and common Glaſs, and mixing them, melted them together; but the Mixture when in Fuſion took at firſt a beautiful green Colour, and continuing it longer in the Focus, it turned bluiſh. I believe we may attribute this Change of Colour to the Alcali Salts of the Glaſs acting on the Particles of Copper; for thoſe Salts uſually draw a green or bluiſh Tincture from this Metal.

To preſerve therefore this red Colour of the vitrified Copper, when mixed with common Glaſs, I made Uſe of this Expedient. I melted in the Focus upon a Coppel a Piece of Copper, and as ſoon as it began to vitrify, I caſt upon it ſome common Glaſs; as ſoon as the Glaſs was melted, I took them together out of the Focus without confuſing them; and as ſoon as they were cold, ſeparated the Regulus from the Glaſs as well as poſſible; and picked out of it ſome Pieces of the Glaſs, loaded with ſome very ſmall red tranſparent Particles of the Regulus.

This vitrified Copper is then nothing but Copper, deprived, by Means of Heat, of the ſulphureous Part, that gave it the Form of a Metal. A Proof, that this metallick Form proceeds from nothing elſe but this Sulphur, is, that if one expoſes this vitrified Copper to the Focus upon Charcoal, it reaſſumes, in a little Time, the Colour and Conſiſtence of melted Copper; and as it grows cold, fixes into a good red malleable Copper, as fine and hard as it was before it was vitrified.

It follows from theſe Experiments, that the Baſis of Copper is a red Earth ſuſceptible of Vitrification.

That this Earth receives its metallick Form from a ſulphureous Subſtance, in Appearance no Ways different from the Oil of Vegetables or Animals.

That one may deprive Copper of this Oil, by holding it long enough in the Focus, or by calcinating it in the Flame of common Fire.

That Charcoal reſtores again this oily Part to Copper, and at the ſame Time its metallick Form.

It appears further, that the Oil of the Coal has not ſo conſiderable an Effect upon Copper, as it has upon Iron.

Copper expoſed a long Time to the Focus upon a Stone or Coppel, fumes very much, and diminiſhes in Weight very conſiderably. I don't think that this Fume is only the ſulphureous Part of the Metal, the Evaporation of which muſt be inſenſible; but I believe that with this Oil there is mixed a great deal of the earthy, vitrifiable Part of the Metal, which the Heat of the Sun ſublimes and raiſes in Flowers.

On Tin. Tin expoſed upon Coal to the Focus of the Burning-Glaſs, melts and emits a groſs, white, thick Fume, until it is all conſumed in Vapours.

If one melts Tin upon a Coppel in the Focus of the Glaſs, it fumes very much, and its Surface is covered with a white rarefied Calx; on which, by little and little, ariſes a Tuft, or Heap of ſharp, Needle-like, tranſparent chryſtalline Particles, conſiſting of an infinite Number of ſmall Points.

If one continues to hold this Maſs in the Focus upon the Stone, theſe Chryſtals at Length leave off fuming, and remain fixt, while the Stone melts and vitrifies.

I took Calx of Tin, which is Tin reduced to a grey Powder by Means of Fire, that has taken away by Calcination great Part of its oily Subſtance, and expoſed it on a Coppel to the Focus, where it fumed again very much, and was reduced into ſharp chryſtalline Particles conſiſting of other ſmall Points.

In re-expoſing theſe chryſtalline Particles to the Focus upon Charcoal, they melted very eaſily, and took again the Form of Tin; the Coal having furniſhed them with the ſulphureous Part that the Fire had before taken away. Every body knows, that if one add any Fat, or the like inflammable Matter, to the Calx of Tin, when red hot in the Crucible, it reaſſumes immediately the Form of Tin.

Theſe Experiments ſhew, that Tin contains a Sulphur that is very eaſily ſeparated, ſince common Fire can do it ſo readily; and that this Metal calcined, or deprived of its Sulphur, is eaſily ſaturated again with it from the oily Part of any inflammable Matter whatſoever.

It proves alſo, that the metallick Earth, which is the Baſis of Tin, is a chryſtalline Earth, very difficult to be melted; ſince common Fire cannot vitrify this Metal by itſelf, and that the Heat of the Sun, in the Focus of this large Burning-Glaſs of the *Palace-Royal*, cannot perfectly melt the Calx, into which this Metal is reduced. We may preſume, that the Chryſtallization, or reducing of this Metal into ſharp-pointed Particles, proceeds from the Force of the Sun's breaking and melting together into a Sodder (if I may ſo ſpeak) ſome of theſe ſmall Chryſtals, by Degrees, as the ſulphureous Part leaves them; it not being ſtrong enough to melt them all down together in one entire Maſs.

On Lead. I took Lead, and held it in Fuſion upon Charcoal in the Focus of the Glaſs: It all waſted away in Abundance of Fumes.

I expoſed the like Quantity of Lead upon a Stone to the Focus, where it caſt forth great Quantities of Fumes, and by little and little changed into a fluid Liquor like Oil or melted Roſin. This Liquor, as it grew cold, fixed into Glaſs; which has this peculiar to itſelf, that it is diſpoſed into Plates like *Venetian* Talk, and that it is flabby, ſoft to the Touch, tranſparent, and in ſome Parts of a greeniſh or reddiſh Yellow.

In continuing this Matter in the Focus, it ſpread upon the Stone like Varniſh; and at laſt penetrating it, helped to melt it.

I placed this talky Earth in the Focus upon Charcoal: It melted, and in a little Time after reaſſumed the Form of melted Lead. I withdrew it from the Focus, and having let it cool, found it nothing different from Lead.

Theſe Experiments ſhew, that there is in Lead, as well as the other imperfect Metals, a ſulphureous Part, that is eaſily ſeparated by common Fire, or the Heat of the Sun; and that this Metal has for its Baſis a foliated or talky Earth.

On Quickſilver.

I ſhall add here ſome Experiments, that I have made upon Quickſilver; though I cannot yet draw any poſitive Concluſions from them, not having proſecuted them ſo far as is neceſſary for that Purpoſe.

I placed Quickſilver in the Focus of the Burning-Glaſs upon Charcoal, upon the Coppel, and upon the Stone: It all immediately diſperſed, and exhaled in a very thick Fume.

I expoſed upon the Stone to the Focus ſome Mercury *Precipitate per ſe*, in a Degree of Heat equal to that of Digeſtion: It ſeemed to melt, but preſently diſperſed in Vapours; there remained a ſmall Quantity of a very rarefied Duſt like a Froth or Scum; but continuing it in the Focus, it melted, and gathered into a yellowiſh Glaſs, in which one might diſtinguiſh ſome Particles of Metal like Silver.

I expoſed ſome Mercury *Precipitate per ſe* upon Charcoal: It fumed very much; and, as it melted, one might ſee little Globules of Mercury unite and form themſelves together upon the Coal, but they diſperſed again preſently in Vapours.

Theſe Experiments ſeem to prove, that there is in Quickſilver a Sulphur, that may be ſeparated by a very gentle Heat, ſuch as that of Digeſtion.

That as ſoon as this Sulphur is taken away, it loſes its Fluidity and Brightneſs.

That the Baſis of Mercury is a Calx, or red Earth.

That this Calx does not melt into Glaſs as the Calx of other Metals, becauſe it is too volatile, and as ſoon as it melts is evaporated by the Heat.

That if one reſtores to this Calx a Sulphur, by expoſing it again to the Focus upon Charcoal, it reaſſumes immediately its metallick Brightneſs and Fluidity, and becomes Quickſilver.

I cannot tell whether this light Earth, that remains upon the Stone after the Evaporation of the Calx of the Mercury, be a Part of the Earth of the Mercury more exactly deprived of its Oil, and conſequently more fixt and proper for Vitrification; or whether it may not be ſome Matter foreign to the Mercury, that fixes itſelf, and remains behind.

behind at its Evaporation. But this I ſhall examine more particularly hereafter.

The Reſult of all theſe Experiments is, that theſe four Metals, which we call imperfect, *viz.* Iron, Copper, Tin, and Lead, are compoſed of a Sulphur or oily Subſtance, and of a metallick Earth capable of Vitrification.

That from this Sulphur proceeds the Opacity, Brightneſs, and Malleability of a Metal.

That this metallick Sulphur does not appear at all different from the Oil of Vegetables or Animals.

That it is the ſame in Mercury as in the four imperfect Metals.

That theſe four Metals have, for their Baſis, an Earth ſuſceptible of Vitrification.

That this Earth is different in every one of theſe four Metals, in that it vitrifies differently in each of them.

And that on this Difference in vitrifying depends the Difference of Metals.

It remains, that I ſhould examine more particularly the Nature of theſe Earths, or metallick Vitrifications, to know if any other Principles or Subſtances may be ſeparated from them: But this I ſhall endeavour to do hereafter, in proſecuting the Analyſis of theſe Metals, as far as poſſible.

Experiments with Mr. Villette'*s Burning-Glaſs in* June, *by Dr.* J. Harris, *and Dr.* J. T. Deſaguliers, n. 360. p. 976.

VI. This Miroir is a Concave 47 Inches wide, and ground to a Sphere of 76 Inches *Radius*; ſo that its Focus is about 38 Inches diſtant from the Vertex of the Glaſs. The Metal of which it is made is a Mixture of Copper, Tin and Tin-Glaſs, whoſe Reflection has ſomething of a yellow Caſt. The Concave-Surface has ſcarce any Flaws, and thoſe very ſmall; but the Convex-Side, which is alſo poliſhed, has ſome Holes in it.

Having held ſeveral Bodies in the Focus of this Miroir, we obſerved what happened to them whilſt expoſed to this great Heat; and with a half-ſecond Pendulum, took Notice of the Time in which any material Change happened to them.

The Experiments were as follow, and made from Nine till Twelve in the Morning.

N° 1. A red Piece of a *Roman Patera*, which began to melt in 3 Seconds, was ready to drop in 100.

2. Another black Piece melted at 4, and was ready to drop at 64 Seconds.

3. Chalk taken out of an *Echinus Spatagus* filled with Chalk only, fled away in 23 Seconds.

4. A Foſſile-Shell calcin'd in 7 Seconds, and did no more in 64.

5. A Piece of *Pompey*'s Pillar at *Alexandria* was vitrified in the black Part in 50 Seconds, and in the white Part in 54.

6. Copper-Oar, that had no Metal in it viſible, vitrified in 8 Seconds.
7. Slag, or Cinder of the ancient Iron-work ſaid to have been wrought by the *Saxons*, ready to run in 29 Seconds and an half.

Here the Glaſs growing hot, burned with much leſs Force.

8. Iron-Oar fled at firſt, but melted in 24 Seconds.
9. Talk began to calcine at 40 Seconds, and held in the *Focus* 64.
10. *Calculus humanus* in 2 Seconds was calcined, and only dropped off in 60.
11. An anonymous Fiſh's Tooth melted in 32 Seconds and an half.
12. The *Asbeſtos* ſeemed condenſed a little in 28 Seconds; but it was now ſomething cloudy: Monſ. *Villette* ſays, that the Glaſs uſually calcines it.
13. A golden Marchaſite broke to Pieces, and began to melt in about 30 Seconds.
14. A Silver Sixpence melted in 7 Seconds and an half.
15. A King *William*'s Copper Halfpenny melted in 20 Seconds, and ran with an Hole in it in 31.
16. A King *George*'s Halfpenny melted in 16 Seconds, and ran in 34.
17. Tin melted in 3 Seconds.
18. Caſt Iron in 16 Seconds.
19. Slate melted in 3 Seconds, had an Hole in 6.
20. Thin Tile melted in 4 Seconds, had a Hole, and was vitrified through in 80.
21. Bone calcined in 4 Seconds, and vitrified in 33.

An Emerald was melted into a Subſtance like a Turquois Stone.

A Diamond weighing 4 Grains loſt $\frac{7}{8}$ of its Weight.

VII. Experience (as well as the Authority of Dr. *Hook* in his Preface to his *Micrographia*) aſſures us, that ſingle Magnifying-Glaſſes (when they can be uſed) are preferable to Microſcopes, compoſed of two or more Magnifying-Glaſſes: Nor are the late Improvements, made by Magnifying-Glaſſes, ſo much owing to the making *Them*, and compoſing *Microſcopes*, as to the *Methods* of applying Objects for the *Advantage* of Light; in which, I hope, the following deſcribed *Inſtruments* will not be found inferior to any yet made, at leaſt commonly ſold.

A Pocket-Microſcope, by Mr. J. Wilſon, n. 281. p. 1241.

This *Sett* of Microſcopes has eight different Magnifying-Glaſſes; ſeven of which may be uſed with two different Inſtruments, for the better applying them to various Objects: One of theſe Inſtruments is repreſented *Fig.* 72. *AAAA*, and is made of Ivory; it has three thin Braſs Plates *EE*, and a Spring of Braſs *H* within it; to one of the thin Plates of Braſs is fixed a Piece of *Cork F*, with a Concavity *G*..... both in the Cork and Braſs to which it is affixed: In one End of this Inſtrument

Fig. 72.

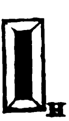
Inſtrument there is a long Screw *D*, with a Glaſs *C*, ſcrewed in the End of it: In the other End there is a hollow Screw *o o*, wherein any of the Magnifying-Glaſſes are ſcrewed when they are to be made Uſe of. The 8 different Magnifying-Glaſſes are all ſet in Ivory, 7 of which are ſet in Fig. 76. the Manner of *Fig.* 76. *n.* 4. The greateſt Magnifyer is marked upon the Ivory, wherein it is ſet, with *n.* 1. the next *n.* 2. and ſo on till *n.* 7. the 8th Glaſs is not marked, but ſet in the Manner of a little Barrel Fig. 74. Box of Ivory, as in *Fig.* 74.

Fig. 73. *Figure* 73 is a flat Piece of Ivory *e e*, whereof there are 8 belonging to this Sett of Microſcopes, (though any one, who has a Mind to keep a Regiſter of Objects, may have as many of them as he pleaſes) in each of which there are 3 Holes *f f f*, wherein 3 or more Objects are placed between two thin Glaſſes or Talks, when to be uſed with the greateſt Magnifyers.

Fig. 75. The Inſtrument *Fig.* 75. is made of Braſs or Prince's Metal, with Joints *P P P*, to turn eaſily any Way with a ſmall Pair of Tongs *G G*, which open at the Points *k*, by preſſing together the two Heads of the Pins *I I* for taking up of Objects: There is a round Piece of Ivory *H*, ſcrewed upon the other End of the Tongs, white on one Side for black Objects that are opaque Bodies, (ſuch as are Seeds or Sands) and black on the other Side for white ones of that Nature.

Upon the ſharp End *A*, of this braſs Inſtrument, all the 8 Glaſſes Fig. 76. may be fixed, as you ſee *Fig.* 76. *n.* 4. there being a Hole in the Ivory wherein the Glaſſes are ſet for that Purpoſe, with a thin Piece of Braſs *B* in the Manner of a Spring, that holds it firmer: So when any Object is taken up in the Points of the Tongs *k*, or laid upon the other End *H*, it may be very eaſily (as any one who ſees the Inſtrument will perceive) applied to the true Diſtance of any of the Glaſſes, by the Help of the Joints *P P P P*, as alſo the Screw *C*, and Wheel *D*, which will bring the Object to the Exactneſs of the *Center* or true Diſtance, being regulated by a Spring *E*.

Fig. 72. The Uſe of the firſt mentioned Inſtrument, *Fig.* 72. *A A A A*, is thus: Fig. 73. Take one of the flat Pieces of Ivory *e e*, or *Regiſters*, *Fig.* 73. (as they may be called) and ſlide it in betwixt the two thin Plates of Braſs *E E*, in the Body of the Microſcope, *Fig.* 72. ſo that the Object, you intend to look upon, be juſt in the Middle, remarking, that you put that Side of the Plate *e e*, where the Ring is furtheſt from your Eye: Then you are to ſcrew into *o o* (the hollow Screw in the End of the Body of your Microſcope) the 3d, 4th, 5th, 6th, 7th Magnifying-Glaſs; which being done, while you are looking through the Magnifying-Glaſs upon the Object, you are to ſcrew in or out the long Screw *D* in the other End of the Body of the Microſcope, till you bring the Object to the true Diſtance; which you will know by ſeeing the Object clearly, and diſtinctly: But ſince in the greater Magnifyers you can ſee but a ſmall Part of the Object, *viz.* the Legs or Claws of a Flea; while you are looking upon any Part of the Object, if you take hold of the End of the



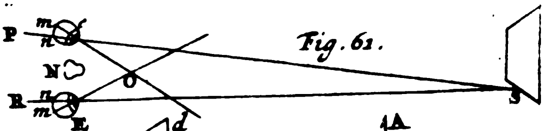
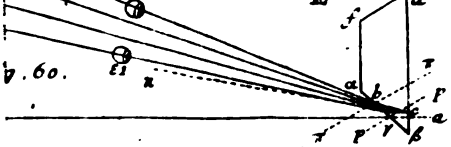


Fig. 61.


g. 60.

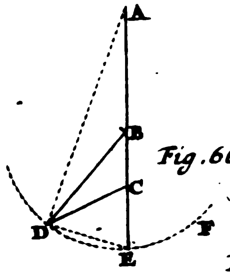
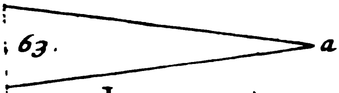


Fig. 66.


63.

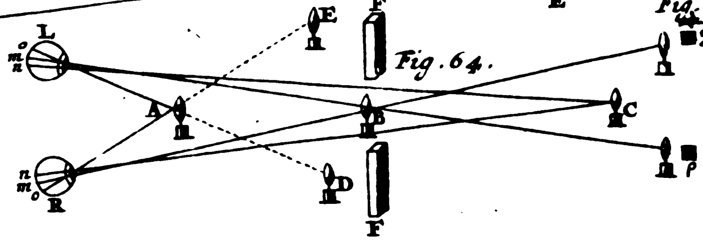
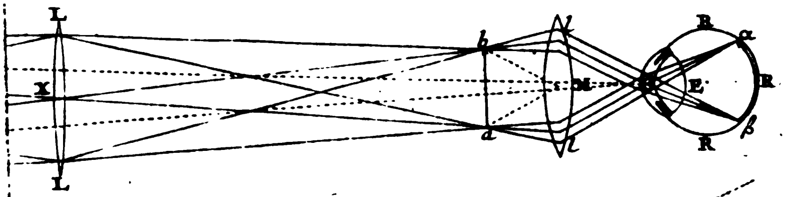


Fig. 64.

Fig. 65.



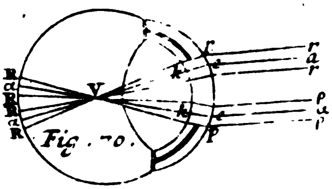


Fig. 70.

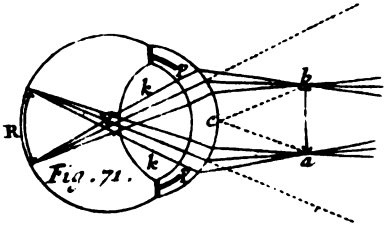


Fig. 71.

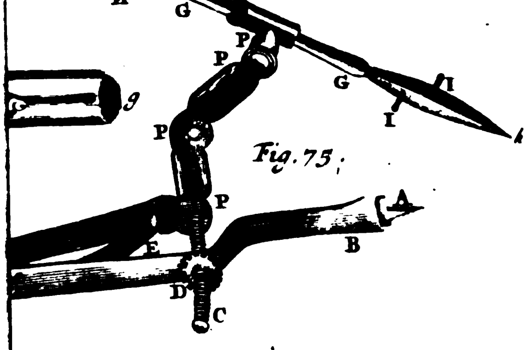


Fig. 75.

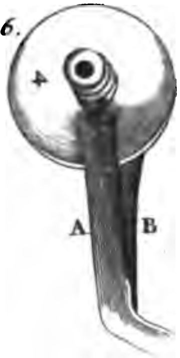


Fig. 76.

the Plate *e e*, whereon the Object lies, and move it gently, you may ſee the whole Object ſucceſſively, or any Part of the Object you pleaſe; and if that Part of the Object, you deſign to look upon, be out of the true Diſtance, remember your End-ſcrew *D* can always bring it in, by ſcrewing it nearer or farther off.

After this Manner may be ſeen all tranſparent Objects, Duſts, Liquids, Chryſtals of Salts; ſmall Inſects, ſuch as Fleas, Mites, &c. If they be Inſects that will creep away, or ſuch Objects as one intends to keep, they may be placed between the two *Regiſter-Glaſſes ff*. For by Fig. 73. taking out with the Point of a Penknife the Ring that keeps in the Glaſſes *ff*, where the Object lies, they will fall out of themſelves; ſo you may lay the Object between the two hollow Sides of them, and put the Ring in as it was before: But if the Objects are Duſts or Liquids, a ſmall Drop of the Liquid, or a little of the Duſt laid on the Outſide of the Glaſs *ff*, and applied as before, will be ſeen very eaſily.

As to the firſt and ſecond Magnifying-Glaſſes, being marked with a Croſs upon the Ivory wherein they are ſet, they are only to be uſed with thoſe *Regiſter-Plates*, that are alſo marked with a Croſs, wherein the Objects are placed between two thin Talks, becauſe the Thickneſs of the Glaſſes, in the other Regiſters or Plates, hinders the Object from approaching to the Centre, or true Diſtance of theſe great Magnifyers. But the Manner of uſing them is the ſame with the former; only remember when you put in or pull out the ſame Plate or Regiſter *e e*, Fig. 73. (whereon the Object lies) or move it from one Object to another, not to let it rub your Magnifying-Glaſs, which is done by unſcrewing a little the End-ſcrew *D*, when you put in or pull out the Plate, or move it Fig. 72. from one Object to another.

For ſeeing the *Circulation* of the *Blood* at the Extremities of the *Arteries* and *Veins*, in the tranſparent Parts of Fiſhes, Eels, &c. there are two Glaſs-Tubes, the one bigger and the other leſſer, is deſigned in *Fig*. 77. wherein the Fiſh is to be put; when this leſſer Tube is Fig. 77. uſed, you are to unſcrew the End-ſcrew *D* in the Body of the Microſcope until the Tube *g g*, *Fig*. 77. can eaſily enter into that little Cavity *G* of the Braſs-Plate faſtened to the Cork *F*, under the other two Fig. 72. thin Plates of Braſs *E E*; when the Tail of your Fiſh lies flat to the Glaſs Tube, ſet it oppoſite to your Magnifying-Glaſs, and by ſcrewing in or out the End-ſcrew *D*, as is ſaid before, you may eaſily bring it to the true Diſtance, and ſee the Blood circulate with great Pleaſure.

When the bigger Tube is to be uſed with a larger Fiſh or Frog; then you are to take out the Braſs-Plate *G F* faſtened to the Cork, by preſſing Fig. 72. down the other two Plates *E E*, and the Spring *H*, to the End of the Microſcope *B*; and by turning the Cork and Braſs-Plate *G F* ſideways, you may eaſily take it out, and put it in again; when the Cork-Plate *G F* is out, the larger Tube will eaſily enter into the Body of the Inſtrument, and is to be uſed as the other leſſer one.

If you would ſee the Blood circulate in a Frog's Foot, chuſe ſuch a Frog as will juſt go into your Tube, then with a little Stick expand the hinder Foot of the Frog, and apply it cloſe to the Side of the Tube, obſerving, that no Part of the Frog hinders the Light coming on its Foot; and when you have it at the juſt Diſtance by Means of the Screw *D*, as abovesaid, you will ſee the rapid Motion of the Blood in its Veſſels, which are very numerous, in the tranſparent thin Membrane that is between the Frog's Toes: For this Object the 3^d^ and 4^th^ Magnifyers will do very well; but you may ſee the Circulation in the Tails of *Water-Newts* with the 5^th^ and 6^th^ Glaſs, by Reaſon the Globules of the Blood of thoſe Newts are as big again as the Globules of the Blood of Frogs or ſmall Fiſh, as has been taken Notice of by Mr. *Cowper* in N° 280, of theſe *Tranſactions*. *Vid.* infra V. v. C.VI. S.iii.

N. B. The Circulation cannot be ſo well ſeen by the 1^st^ and 2^d^ Magnifyers, becauſe the Thickneſs of the Glaſs wherein the Fiſh lies, hinders the Approximation.

Fig. 74. The Glaſs placed in the Manner of a Barrel-Box, *Fig.* 74. is only to be uſed with the Braſs Inſtrument, (or in your Hand) being the leaſt Magnifyer for greater Objects, ſuch as Flies and common Inſects, *&c.* The Hole *a* in the Side of this Box is to be fixed on the Point *A* of the Braſs Inſtrument, remembring to put the End *b* next your Eye, and the other to the Object; ſo if you take up any Inſect in the Point of the Tongs *k*, or lay any opaque Object on *C*, the other End, you may approach them to the true Diſtance, by the Help of the Joints and Screw *C*, *D*, *P*, *E*, (ſpoken of before) and ſee them diſtinctly. Fig. 75.

In the Viewing of Objects, one ought to be careful not to hinder the Light from falling upon them, by the Hat, Peruke, or any other Thing, eſpecially when they are to look upon opaque Objects: For nothing can be ſeen with the beſt of Glaſſes, unleſs the Object be in a due Diſtance, with a ſufficient Light.

The beſt Light for the Plates or Regiſters, (where the Object lies between the two Glaſſes) is a clear Sky-light, or where the Sun ſhines on any white Thing, or the Reflection of the Light from a Looking-Glaſs. The Light of a Candle is likewiſe good for the Circulation of very ſmall Objects, though it be a little uneaſy to thoſe who are not practiſed in Microſcopes to find out the Light of the Candle; but Uſe will make every Thing eaſy.

For the Conveniency of thoſe who would *draw* or make any Sketches or Deſigns after Microſcopical Objects, I have alſo made a *Pedeſtal* to fix the two Inſtruments above deſcribed, and make them ſtationary to any convenient Light. This Pedeſtal may be placed on a Table, *&c.* and after the Object, and Light are fixt, as many Perſons as pleaſe may view the Object, without any Trouble or Difficulty in finding the Light.

Some Objects viewed with this Microſcope.

The following Figures were drawn by this Microſcope from ſeveral Objects:

Fig. 78.

A, B, C, D, E, F repreſent the Feathers of the Wings of *Butterflies* and *Moths*; *A, B* are the ſame, but differently magnified. *A* was expreſſed by the 4th Glaſs, and *B* as it appeared by the 1ſt. The reſt being taken from different Parts of thoſe *Inſects*, *C, D, E, F* were all viewed by the 4th Glaſs.

G is one Grain of the *Farina* of the *Capilaments* of *Maloes* by the *firſt* Glaſs. Fig. 79.

H H is the *Tail* of a ſmall *Fiſh*, viewed when living by the 4th Glaſs; Fig. 80. *i i* is the Part of the Tail next the Body of the Fiſh, where the Trunks of the *Veins* and *Arteries* paſs together. *I I I I* their *Extremities* which appear united, *k k k* other *Inoſculations*, with the *Arteries* and *Veins* appearing in the tranſparent Membrane, between the Cartilages *K K*. *L L L L* the *Cartilages* compoſed of ſeveral Joints, on each Side of which the Trunk of a Vein and Artery paſſes. *M* an *Animalculum*, whereof a great Number appeared moving themſelves up and down on the Tail of the Fiſh, while the Circulation was viewing. Fig. 81.

N repreſents a Side-view of the ſame *Animalculum*. Fig. 82.

O is another *Animalculum* of a different Figure from the former, that ſtuck to the Tail of the Fiſh by its jagged Extremity, and frequently drew its long Body out and in again. Fig. 83.

P Q one of the *Lice* found on the *Beetle*, called *Scarabeus Pediculoſus* by the 4th Glaſs. *P* its *Anus*. *Q* its two Claws, not unlike thoſe of a Lobſter, *r r r r* the Extremities of its Feet, which have a remarkable Contrivance for ſticking faſt to the poliſhed Surface of the Beetle, not in the Manner of Claws, as many other Inſects, but divided into Capilaments, as expreſſed in the Figure. Fig. 84.

S the ſame *Animal* as it appeared to the naked Eye. Fig. 85.

The Manner of making Microſcopes, &c. *by Dr.* A. Adams, n. 325. p. 24.

VIII. I think that all the Microſcopes, which preceded Mr. *Leeuwenhoeck*'s, are ſo much out-done by his, that it will be proper only to take Notice of theſe and the reſt of later Invention, not deſigning to leſſen their Uſefulneſs, but only to add a few Thoughts which may be of Service.

I had not an Opportunity of examining Mr. *Leeuwenhoeck*'s Glaſſes particularly, which is a Favour he allows to none; therefore I am not capable at this Diſtance to deſcribe either their Make or Uſe, any further than that to me they appeared to be Spherules lodged between two Plates of Gold or Braſs, in a Hole whoſe Diameter might not be bigger than that of a ſmall Pin's Head; and the Objects I ſaw through them were pretty and diverting; but ſtill their Make and Truth are unknown.

Mr. *Butterfield* is very curious in melting his Glaſs, but I ſuppoſe unſucceſsful in caſting his Spheres; for beſides that a ſufficient Quantity of beaten Glaſs cannot ſtick to the moiſtened Point of a fine Needle;

ſo neither can it run equally, hold the Needle how you will, nor the *Globule*, when run, ſtick to the Needle, but muſt unavoidably drop; and whereſoever it happens to fall, it muſt in that almoſt liquid State receive Impreſſions ſufficient to ſpoil the Figure of a Sphere.

Mr. *Gray* has ſhewn the Defect of his Method, which he uſed to recover by grinding and poliſhing his Glaſſes on a Braſs-Plane, and ſo reduce them to Hemiſpherules; but how far ſhort poliſhed Glaſſes (I ſpeak of ſmall ones) come of thoſe which are caſt, I leave to any one to judge who has ſeen both. His Water and Quickſilver Microſcopes I never ſaw, ſo can ſay little to them.

After what Manner Mr. *Wilſon*'s Glaſſes are made I know not, but ſure his greateſt Magnifyers are ill placed, they being ſunk to ſo great a Diſtance from the Eye, the Object cannot appear to that Advantage it otherwiſe would; if therefore inſtead of a hollow Cap, he would contrive a plain Plate of any Metal for the Reception of the Glaſs, then the Eye and the Object might come to their due Diſtance; neither ought there to be any Calx or Glaſs between the Object and the Spherule, when we uſe the greateſt Magnifyers; becauſe if the *Focus* of a Sphere be upon the Extremity of its Circumference, any ſmall Diſtance from that muſt ſpoil the Truth of the Object's Appearance.

I cannot ſay, that the Glaſſes I have made are without Fault, but I think they magnify more than any I have yet ſeen; and were they placed to the beſt Advantage, they would magnify much more than they do: They are made thus.

I take a Piece of fine Window-Glaſs, and I raſe it with a Diamond into as many Lengths as I think needful, not exceeding an Eighth of an Inch in Breadth; then holding one of theſe Lengths between the Fore-finger and Thumb of each Hand, over a very fine Flame, until the Glaſs begins to ſoften, I draw it out till it be as fine as a Hair, and break: Then inuring each of the Ends into the pureſt Part of the Flame, I have two Spheres preſently, which I can make larger or leſs as I pleaſe; if they ſtay long in the Flame, they will have Spots, ſo I draw them out preſently after they turn round. As for the Stem, I break it off as near the Ball as I can, and lodging the Remainder of this Stem between the Plates, and by drilling the Hole exactly round, all this Protuberance is buried between the Plates, and the Microſcope performs to Admiration; inſomuch, that the ſame Thread of very fine Muſlin appeared 3 or 4 Times bigger in one of theſe, than it did in the firſt or ſecond of Mr. *Wilſon*'s. I thought I ſaw Animals in fine old Brandy; but they were ſo nimble in their Motion, that I can give no particular Deſcription of them. Human *Blood* is ſo far from ſhowing any red *Globules* ſwimming in *Serum*, that immediately after its *Emiſſion* it appears to be a Body of infinite Branches, running in no certain Order, variouſly coloured; where it lies thickeſt on the Glaſs, it is of a dull Red; where thin, inclining to Yellow; but the Whole ſo blended, as to repreſent very near the Top of a Yew-

A Remark on Blood.

Tree in a very fine Landskip, having its ſuppoſed Branches of a Red and Yellow confuſedly intermixt. But not ſatisfied with this Appearance, though the ſame as to Quality in eleven different Glaſſes, and as many different Sorts of Blood, I reſolved to view it another Way, which was, by diluting one Third of Thick in the *Serum* of Blood; and laying it upon my Glaſs, I could ſee the red Branches as before, and the Tranſparent filled with Particles of great Variety of Figures, which I took to be the Salts of the Blood, but feweſt globular, and they were pellucid.

If the Fluids moving in an evaneſcent Artery appear globular, I ſuppoſe it is becauſe the Canal is round, which alters the Caſe much.

——*on Pleuritic Blood.*

I had at the ſame Time an Opportunity of viewing ſome *Pluritic* Blood; and thought that its Branches did ſpread in a different Method from the Sound, and more ſtrongly perplexed with overthwart Branches, which appeared black like Blood that had ſtood two or three Days. Whether the Attraction of Particles ariſing from the Difference of Figure, may not render the Blood incapable of paſſing through the capillary Arteries of the *Pleura* in that Caſe, let others judge; but I ſhould think, that ſince the propellent Force of the Heart is leaſt at the capillary Arteries, then there the attractive Force of the Particles of the Blood ſhould be greateſt; and ſince Spherical Bodies are the moſt attractive of any, Reſpect being had to their Solidities, were the Blood ſo plentifully ſtocked with Globules, as ſome ſay, we ſhould never be free from Obſtructions, the natural Conſequence of this attractive Force. If my Glaſſes have deceived me, and if this that I have written be found to be a Miſtake, no one ſhall more readily retract and acknowledge it.

IX. *Account of a Book omitted.*

Linear Perſpective, or a *new* Method of *Repreſenting* juſtly all Manner of Objects, *&c.* By *Brook Taylor*, LL. D. and R. S. *Secr.* 8^vo^. London, 1715. N. 344. p. 300.

An Addition ibid. p. 303.

The Author having in his *Book* obſerved, that there might be a very good *Expedient* made Uſe of in painting of large Rooms and Churches, which is drawn from the Nature of thoſe Rays which produce the *Vaniſhing Points*, but not having mentioned it in his Book, has thought proper to take Notice of it in the *Account*.

The *Expedient* is this: Having ſome Way or other found the Repreſentation of one Point of a Line that is wanted in the Picture, to find the whole Line, paſs a Thread ſtretched through the Place of the Spectator's Eye, in a Direction, parallel to the Direction the original Line ought to be in, and the Shadow of that Thread caſt by a Candle, ſo as to paſs through the given Point on the Picture, will be the Repreſentation ſought. The Reaſon of this Conſtruction is, becauſe the Rays of Light that paſs from the Candle to the Thread ſo ſtretched, make the Plane which generates the Repreſentation ſought; (*Vid.* Prop. 1.) and there may be other Expedients of the like Nature gathered from the ſame Principle.

CHAP. III.

CHAP. III.

ASTRONOMY.

Of Caſſini's *Orbit of the* Planets, *by* Dr. Gregory, n. 293. p. 1704.

I. SINCE the Time that the celebrated Mr. *Caſſini*, in his Treatiſe *of the Origin and Progreſs of Aſtronomy*, has propoſed to the Aſtronomers a certain Curve for the Orbit of a Planet; there has been much Debate among the Learned concerning the Nature of this Curve, and the Law of Gravitation required in order to its being deſcribed. As I have thought again upon the ſame Subject, not only the different Species of this Curve, but ſome of their Properties not ſufficiently examined, have occur'd to my Enquiries.

Fig. 86. It is now well known, that the Nature of this Curve is this. If from two given Points *F* and *G* to any Point of the Curve *H* two Lines are drawn *FH* and *GH*; the Rectangle under *FH* and *GH* is equal to a given Space. The right Line *FG*, being produced each Way till it meets the Curve, will ſhew the two Vertices *A* and *B*; and *AB* is the principal Axis. And *C* the middle Point between the Vertices will be the Center of the Figure. And *DE* drawn through *C* perpendicular to *AB* will be the leſſer Axis: And the Points *F* and *G* are the Foci.

In this Figure, if the leſſer Axis is greater than the Diſtance of the Foci, the Curve terminating the Figure is every where concave towards the Center, ſuch as the Figure is commonly deſcribed. But if the Diſtance of the Foci is leſſened, while the principal Axis continues the ſame, the leſſer Axis will be increaſed, which yet remains leſs than the Axis of an Ellipſis, deſcribed with the ſame principal Axis and the ſame Foci: Till at laſt when the Foci unite, it becomes equal to the greater Axis, and the Figure changes into a Circle. But on the contrary, if the Diſtance of the Foci increaſes, the leſſer Axis will be leſſen'd, and will become equal to the ſaid Diſtance, when this is to the principal Axis, as Unity is to a mean Proportional between Unity and the Number 3.

Fig. 87. If the Diſtance of the Foci be farther encreaſed, the leſſer Axis will be ſtill leſſen'd, and the Curve at its Extreams will be no longer concave towards the Center, but convex as in *Fig.* 87. till the Diſtance of the Foci being ſo far increaſed, that it is to the greater Axis, as the Side of a Square to its Diameter; the leſſer Axis will become nothing, and the Curve will reach on each Side to the Center.

Fig. 88. If the Diſtance of the Foci is greater than the aforeſaid ratio, the leſſer Axis becomes impoſſible, and the Figure changes into two conjugate Figures, as in *Fig.* 88. which will be leſſen'd as the Diſtance of the Foci increaſes, till at laſt the Figures paſs into two conjugate Points only.

The Diſtance of the Foci ſtill increaſing, the two conjugate Figures emerge again, which increaſe in the ſame Manner as they decreaſed before, being different from the former in the Order of the Foci and Vertices, and go on increaſing till they become infinite. And afterwards this Syſtem will again approach to the Circle by the ſame Degrees as before it receded from it.

Hence it appears at the firſt View, that this Figure cannot be at all proper to conſtitute the Orbit of a Planet. For not to mention the Caſe wherein it becomes two Figures, and forſakes the Nature of an Orbit, that is, whenever its Excentricity is ſo great as the Comets require, (if they turn about the Sun like Planets, as is moſt probable) to deſcribe their reſpective Courſes: To paſs over theſe Caſes, as ſaid before, even in thoſe Caſes in which it returns into itſelf, and compleats its Orbit, ſome of its Excentricities are ſo large, that near *D* and *E* the Curve becomes convex towards the Sun, and therefore the Planet would have Occaſion for a Centrifugal Force from the Sun, that it may deſcribe this Part of its Orbit, whilſt at the ſame Time both in Places that are nearer and more remote *B* and *A* there ought to be a Centripetal Force towards the Sun. That is, it muſt be allow'd, that the Circumſolar Bodies may move by ſuch a Law, that at equal Intervals from the Sun here a Centripetal Force, and there a Centrifugal can obtain, which how contrary it is to the known Laws of Nature is eaſy to perceive. And tho' none of the Planets have ſo great Excentricity, yet ſince it is known to Geometricians, that if all the Species of a Figure beyond a certain Limit are unfit for performing a natural Function, the remaining Species of that Figure on this Side the Limit, cannot be admitted as fit for performing the ſame Function: This Curve of *Caſſini's* muſt of Neceſſity be rejected out of Aſtronomy, not only for the Reaſons alledged, *Prop.* 8. *Lib.* 3. of the Elements of Aſtronomy, *that it neither agrees to the Obſervations of the Heavens, becauſe of the Brevity of the ſhorter Axis, nor do Phyſical Reaſons correſpond, ſince for the Deſcription of this a Centripetal Force towards the Sun is required, greatly deviating from that which Nature makes Uſe of*; but likewiſe becauſe of the utter Impoſſibility of it. For it is impoſſible that any Species of this Figure ſhould be deſcribed by a Planet, ſo that the Angles at that Focus, which is different from the Sun, may be proportional to the Times; for thus the Area deſcribed by the Radius tending to the Sun could not be proportional to the Times. For the Angle at one Focus being increaſed by equal Increments, the contemporary Increments of the Area to the other cannot become equal; contrary to the Opinion I lately entertain'd of this Matter. Fig. 87.

In Figures 87, 88. the greateſt Breadth of the Figure is found, if with Center *C* a Circle is deſcribed thro' the Foci; for this will cut the Curve in the Points *L*, *L*, which are the Points required. And the greateſt Ordinate *KL* is a third Proportional to the right Lines *GF*, and *FD* is the firſt of theſe, or a fourth Proportional to *GF*, *GA*, and *AF*, in both of them. Fig. 87, 88.

DE remaining, the Ordinate *FP* from the Focus is equal to the leſſer Semiaxis *CD*, when the leſſer Axis is to the Diſtance of the Foci, as the Side of a Square is to its Diameter. If the Diſtance of the Foci is greater than in this ratio, *FP* will exceed *CD*.

The Newtonian *Solution of* Kepler's *Problem demonſtrated*, &c. *by Dr.* J. Keil, n. 337. p. 1.

II. *Kepler* was the firſt that demonſtrated, that the Planets were not carried about in Circular Orbits, but in Elliptical ones; and that they ſurrounded the Sun, placed in one of the Foci of the Ellipſis in ſuch a Manner, that a Radius extended from the Planet to the Sun's Center, alway deſcribes Elliptical Areas, which are proportional to the Times of Deſcription.

This Divine Diſcovery of the moſt ſagacious *Kepler* is owing to the very exact Obſervations of *Tycho Brahe*; and is ſo much the more to be eſteemed, that by the Help of this *Newton* has moſt happily laid open the Laws of Motion, and the Philoſophy of the Syſtem of the Univerſe.

Since therefore the Planets move about the Sun according to this Law, that their Places in their own Orbits may be determined to any given Time, there is Occaſion that the following Problem ſhould be ſolved.

To find the Poſition of a right Line, which paſſing through either of the Foci of a given Ellipſis, may cut off an Area deſcribed by its Motion, which may be to the whole Area of the Ellipſis in a given ratio.

Fig. 89. Let the Ellipſis be *APB*, either of whoſe Foci is *S*. The Poſition of the right Line *SP* is to be found, which may cut off the Trilinear Area *ASP*, to which the Area of the whole Ellipſis has the ſame ratio, as the periodical Time of the Planet deſcribing the Ellipſis, has to any other given Time. This being found, the Point *P* will be given, where the Planet will be at that given Time. Or let *AQB* be a Semicircle deſcribed upon the greater Axis of the Ellipſis; a Line *SQ* is to be drawn thro' *S* cutting off the Area *ASQ*, to which the Area of the whole Circle is in the ſame ratio. For if from *Q* a Perpendicular *QH* is let fall upon the Axis, meeting the Ellipſis in *P*; drawing the Line *SP* it will give the Elliptic Area required, and the Point *P* will be the Place of the Planet at the given Time. For the Semiſegment of the Ellipſis *APH* is to the Semiſegment of the Circle *AQH*, as *HP* to *HQ*; that is, as the Area of the whole Ellipſis is to the Area of the whole Circle. But the Triangle *SPH* is to the Triangle *SQH* in the ſame ratio of *PH* to *QH*. Therefore the Area *ASP* is to the Area of the whole Ellipſis, as the Area *ASQ* is to the Area of the whole Circle. Therefore if we had a Method of cutting the Area of the Circle in a given ratio, by a Line drawn through the given Point *S*, it would be eaſy to cut the Elliptic Area in the ſame ratio.

Kepler himſelf, who firſt propoſed the Problem, had no direct Method of computing the Planets Place from the Time being given. He was fain to proceed thro' the ſeveral Degrees of the Semicircle *AQB*, from the given Arch *AQ*, which they call the Anomaly of the Excentrick, and to calculate as well the Time by the Area *ASQ*, which is proportional to the mean Anomaly, as the Angle ASP, that is the Place of the Planet, or the coequated Anomaly correſponding to this Time.

Therefore as the Solution of this Problem was difficult, Aſtronomers betook themſelves to other Hypotheſes, feigning ſome other Point to be that, about which the Motion was equable or proportional to the Time, and thence the mean Anomaly being given, they determined the coequated Anomaly. But Computations founded upon theſe Hypotheſes were found not to agree with the Obſervations. Therefore Geometers had Recourſe to various Approximations, by which from the given Area ASQ, which is analogous to the Time, the Angle ASP, or the Place of the Planet may be had very nearly. But the eaſieſt of all theſe, and moſt ready for Practice, ſeems to me to be that Method which is taught by Mr. *Newton* in his *Principia*, p. 111, and 112. of the firſt Edition, which is very much like that Method, by which Analyſts extract the Roots of affected Equations; and indeed is ſo much the more to be eſteemed, as that it not only exhibits the Places of the Planets, whoſe Orbits approach very nearly to the Form of Circles, but almoſt with the ſame Facility may be applied to Comets, which move in Orbits that are very excentrick.

Therefore I thought it not amiſs to explain that Method here, for the Sake of ſuch Artiſts as are deſirous of conſtructing Aſtronomical Tables, according to the true Laws of Motion, and not by any fictitious Hypotheſes.

Therefore let AQB be a Semicircle deſcribed upon the greater Axis Fig. 90. of an Ellipſis, whoſe Center is C, and S is the Focus in which the Sun is placed. Let CQ be drawn, upon which, produced if Need requires, let fall the Perpendicular SF. The Area ASQ is equal to the Sector ACQ added to the Triangle $CSQ = \frac{1}{2} CQ \times AQ + \frac{1}{2} CQ \times SF$; and therefore becauſe of $\frac{1}{2} CQ$ being given, the Area ASQ will always be proportional to the Arch AQ, added to the right Line SF, when the Motion is from the Aphelium towards the Perihelium. But when the Planet tends from the Perihelium towards the Aphelium, as in *Fig.* 92. the Area $BSQ =$ Sector $BCQ -$ Triang. CSQ, and therefore it will be proportional to the Arch $BQ -$ right Line SF. Hence if there is taken the Arch AN, in *Fig.* 90, 91. and BN in *Fig.* 92. proportional to the Fig. 90, 91, 92. Times, it will be $AQ + SF = AN$, and $BQ - SF = BN$. Whence SF will be equal to QN, if AN or BN are proportional to the Times in which the Areas ASQ or BSQ are deſcribed. Now that the Meaſure of the Arch in the Periphery AQB, which Arch is equal to the right Line SF, may be found in Degrees and Parts of a Degree: Let it be made as CQ to CS, ſo is the Arch of 57,29578 Degrees, (which is equal to the Radius CQ) to a fourth Arch, which will be equal to CS. Let that Arch be B. But it is CS to SF, as Radius to the Sine of the Angle SCF or ACQ. Therefore let it be made, as Radius to the Sine of the Angle ACQ or the Arch AQ, ſo is the Arch B to another D; that Arch D will be equal to the right Line SF; therefore if, at a given Time, the Area ASQ were proportional to the Time, the Arch D would be equal to NQ; and taking the Arch $NP = D$, the Point P would fall upon Q. But if the Area ASQ ſhould not exactly anſwer to the Time, the Point P will fall above or below Q, according as the Area ASQ is greater or leſs than the true Area which anſwers to the Time. Let it be ASQ, and let SH fall perpendicularly upon Cq. By what has before been demonſtrated, it will be $SH = Nq$. But it is $SF = NP$, whence it will be $SH - SF$, or $SF - SH$, that is nearly $HE = qP = QP - Qq$, or $Qq - QP$. And if the Angle QCq be a ſmall one, it will be $CH . CQ :: HE . Qq :: QP - Qq . Qq$. Whence $CQ + CH . CQ :: QP . Qq$, when the Arch QA is leſs than a Quadrant. But when it is greater than a Quadrant, it will be $CQ - CH . CQ :: QP . Qq$. And in like Manner when the Arch BQ is leſs than a Quadrant, it will be $CQ - CH . CQ :: QP . Qq$.

If the Angle ACQ or BCQ is a ſmall one, that is, if the Planet is near the Apſids, it will be $CA \pm CS . CA :: QP . Qq$.

Let it be made, as CS to CQ, ſo is Radius R to a certain Length L; it will be $CQ = \frac{CS \times L}{R}$. But it is, as Radius to the Coſine of the Angle ACQ, ſo is SC to CF or CH; (for CH and CF are nearly equal) wherefore it will be $CH = \frac{SC \times \text{Coſ.}\, ACQ}{R}$; and therefore $QP . Qq :: \frac{CS \times L + CS \times \text{Coſ.}\, ACQ}{R} . \frac{CS \times L}{R} :: L + \text{Coſ.}\, ACQ . L$, when the Arch AQ is leſs than a Quadrant. But if AQ be greater than a Quadrant, it will be $QP . Qq :: L - \text{Coſ.}\, ACQ . L$.

And in this Method if an Arch AQ be any how taken, which is ſomething leſs or greater than the Truth, thence will be found an Arch Qq to be added to it, or taken from it, which will make the Area ASq very nearly proportional to the Time. And if inſtead of AQ be taken an Arch Aq, and a Proceſs be made with this like the former, another Aq will be found, which in like Manner by repeating the ſame Proceſs, will give another Aq; and thus we may approach as near the Truth as we pleaſe.

The Angle ACq being found, we ſhall eaſily have the Angle ASq, ſince in the Triangle qCS are given the Sides Cq and CS, and the Angle qCS. Thence will be given the Angle CSq, whoſe Tangent is to be leſſen'd in the ratio of the leſſer Axis of the Ellipſis to the greater, that at laſt may be had the Tangent of the Angle ASP. Or perhaps the Angle ASP may be thus found more eaſily. Let F be the Number which expreſſes the Length CS is ſuch Parts as CQ is 100000. From the Point q to the Axis let qr be a Perpendicular, which will be the Sine of the given Arch Aq, and Cr will be the Coſine of the ſame, and Sr will be equal to the Sum or Difference of the right Lines Cr and CS; that is, $Sr = F \pm \text{Coſin.}\, ACq$. Therefore in the right angled Triangle

rSq, Sr and rq being given, the Angle rSq may be found. Hence if the Logarithm of the Sine of the Angle ACq, and the Arithmetical Complement of the Logarithm of Sr, and the Logarithm of the Ratio of the leſſer Axis of the Ellipſis to the greater, be added together into one Sum; the Logarithmical Tangent of the Angle ASP will be given.

But the Readineſs of this Method is ſo great, that it requires rather to be illuſtrated by Examples, than by any farther Explanation. Therefore we may try it in the Motion of the Planet *Mars*, in the Orbit of which, according to the *Caroline* Tables, the Excentricity is to the middle Diſtance, as 14100 to 152369, and therefore the Logarithm of the Arch B, which is equal to the right Line SC, will be 0.7244451. Alſo in this Example L will be 1080631 Parts, ſuch as the Radius is 100000: Let the Angle ACQ be found, when the mean Motion, or the Arch proportional to the Time computed from the Aphelium, is of one Degree. Becauſe CS is here nearly one tenth Part of CA, I ſuppoſe the Arch AQ to be 0.9 Degrees, that is, one tenth Part leſs than the mean Motion. Let there be added the Logarithmical Sine of the Arch AQ to the Logarithm of B, and the Sum 8.9205471 is equal to the Logarithm of the Number 0.083281, which Number expreſſes an Arch equal to the right Line $SF = NP$. And if the Arch AQ had been rightly aſſumed, it would be $AN - NP = AQ$, and $QP = 0$. But here it is $QP = 0.016719$, from whence if we take away its 11 Part, ſince AS exceeds AC by about an eleventh Part of itſelf, there will remain $Qq = 0,0152$; which being added to AQ, gives $AQ = 0.9152$, which does not differ from the true Aq by a thouſandth Part of a Degree. Secondly, let the Arch AN or the mean Motion be 2 Degrees. I make $AQ = 1,83$ almoſt double the former Aq, and to its Logarithmical Sine let be added the Logarithm of B. The Sum will be 9,2286997, which is equal to the Logarithm of the Number 0,16931. Whence it will be $QP = 0,00063$, and $Aq = 1,83063$, which does not differ from the true Aq by the ten thouſandth Part of a Degree. After the ſame Manner let the mean Motion, or the Arch proportional to the Time, be 3 Degrees. Make the Arch AQ $2,745 = 1,83 + 0,915$, and to its Logarithmical Sine adding the Logarithm of B, there will be had the Logarithm of the Number $0,25392 = NP$, and $AN - NP = 2,74608$, and therefore $QP = 0,00108$. Whence $Qq = 0,001$ nearly, and $Aq = 2,746$. Thus by one Addition of two Logarithms, the Arch Aq will be found, which will be true to the thouſandth Part of a Degree.

Now if the Angle ACq is to be found, not by proceeding by Degrees but *per ſaltum*, when the mean Motion is 45 Degrees: I make the Arch AQ to be 40 Degrees, and to its Logarithmical Sine adding the Logarithm of B, the Sum is 0,5325125, which is the Logarithm of the Number 3,4081. This Number ſubtracted from 45 leaves $AN - NP = 41,5919$, whoſe Exceſs above the Arch AQ is 1,5919. Whence if it be made, as $L +$ Coſin. ACQ to L, ſo is 1,5919 to another, the Arch Qq will be found to be 1,4865 Degrees. Therefore $Aq =$

41,4865, which differs from the Truth not much above the thouſandth Part of a Degree. But without this Proportion Aq may be found, by taking a new Arch AQ, which is a little leſs than $AN - NP$, yet nearly equal to it. For Inſtance, make $AQ = 41{,}50$, and adding the given Logarithm of B to its Logarithmical Sine, there will be had another $NP = 3{,}35131$, which ſubtracted from AN gives 41,4869 for a new Aq. And this Arch is derived with leſs Trouble, and comes nearer the Truth than the former Aq.

After Aq is found correſponding to the mean Motion 45 Degrees, proceeding again by Steps, by one Addition of two Logarithms will be had Aq to all the ſubſequent Degrees of the mean Motion. For Inſtance, when the mean Motion is 46 Degrees, I make $AQ = 42{,}4249$; and adding its Logarithmick Sine to the conſtant Logarithm of B, it will be $AN - NP = 42{,}4249$; to which Arch if a new AQ be put equal, there will be had Aq, which will not differ from the true Aq by the thouſandth Part of a Degree. So when the mean Motion is 47 Degrees, I make $AQ = 43{,}36$, equal to the former Aq added to the Increment of that Arch for one Degree of mean Motion, and adding its Logarithmick Sine to the Logarithm of B, the Sum will be the Logarithm of the Number 3,6402, which ſubtracted from AN leaves $AN - NP = 43{,}3593$ equal to the new Aq, which differs from the true Aq about the ten thouſandth Part of a Degree.

If omitting the intermediate Degrees, the Arch Aq is to be found when the mean Motion is 100 Degrees; make AQ 96°, and adding its Logarithmical Sine to the Logarithm of B, the Sum will be equal to the Logarithm of the Number 5,273, whence $AN - NP = 94{,}727$. Therefore, ſecondly, make $AQ = 94{,}72$, and adding its Sine to Log. B. there will ariſe the Logarithm of 5,285, which ſubtracted from AN leaves $AN - NP = 94{,}715 = Aq$ very nearly. In like Manner, if the mean Motion be 101°. make $AQ = 95{,}71$, whoſe Logarithmical Sine added to the Logarithm of B, gives the Logarithm of the Number 5,2756, which Number taken from 101, there will remain $AN - NP = 95{,}7244, = Aq$. And in this Manner the mean Motion being given by a gradual Proceſs the Angle at the Center will be had, by the Addition only of two Logarithms, one of which being conſtant may be preſerved upon the Paper, that the Labour may be ſpared of writing it down too often.

Now let us proceed to an Orbit of the other Species, ſuch as the Diſtance of the Aphelium may be to the Diſtance of the Perihelium, as 70 to 1. Such nearly was the Orbit of that Comet, which compleats its Period in $75\frac{1}{2}$ Years; as was firſt found by that ſagacious Aſtronomer and Geometrician Dr. *Edmund Halley*. In this Orbit AC or CQ will be 35,5 and CS 34,4, of ſuch Parts as SB is one. And the Arch Bq is to be found, when the mean Motion is one hundredth Part of a Degree. Since the middle Diſtance exceeds the leaſt Diſtance about 35 Times, I make $BQ = 0{,}35$, when the mean Motion is 0,01. In this Orbit the conſtant Logarithm of B is found 1,7457133. Therefore this Logarithm being added to the Logarithmical Sine of the Arch 0,35, gives the Logarithm of the Number 0,34013, which added to the Arch 0,01 will make 0,35013. If this Sum had been equal to 0,35, the Arch BQ would have been rightly aſſumed; but the Difference is 0,00013. Whence becauſe CB is to SB as 35,5 to 1, let the Difference 0,00013 be multiplied by 35,5, and there will ariſe $Qq = 0{,}004615$; whence it will be Arch $Bq = 0{,}354615$, which hardly differs from the Truth by three Parts of ten Thouſand.

Secondly, let the mean Motion be 0,02, and ſuppoſe BQ to be 0,71. To its Logarithmick Sine adding the Logarithm of B, the Sum will be the Logarithm of the Number 0,68998; whence $BN + NP = 0{,}70998$, and therefore the aſſumed Arch $BQ = 0{,}71$ was too much, and the Difference is 0,00002. Which if it be multiplied by 35,5, and the Product ſubtracted from BQ, there will remain $Bq = 0{,}7092$, deviating from the Truth hardly the ten thouſandth Part of a Degree.

Let the mean Motion be 0,03. Suppoſe BQ to be 1,06 Degrees, adding its Logarithmick Sine to the Logarithm of B, the Sum will be the Logarithm of the Number 1,03008. To which if $BN = 0{,}03$ is added, the Sum will be 1,06008, which Number is greater than BQ; wherefore if the Difference 0,00008 is multiplied by 35,5, and added to BQ, it will be $Bq = 1{,}06284$. In like Manner, when the mean Motion is 0,04, I ſuppoſe $BQ = 1{,}40$ Degrees, and find $NP = 1{,}3604$; to which Number adding $BN = 0{,}04$, the Sum is 1,4004, which exceeds 1,40 by 0,004. Let this Difference be multiplied by 35,5, and the Product 0,01420 will be equal to Qq; whence $Bq = 1{,}41420$. In all theſe Inſtances the Errors are very ſmall, and ſeldom go beyond the thouſandth Part of a Degree.

Now let the Arch Bq be to be found, when the mean Motion is equal to one Degree. Suppoſe $BQ = 20°$, and adding its Logarithmick Sine to the Logarithm of B, there will be had the Logarithm of the Number 19,045; to which adding $BN = 1°$, the Sum 20,045 exceeds 20 by 0,045. And ſince in this Caſe L — Coſin. BQ is to L, as 1 to 11,5 nearly, I multiply the Difference 0,045 by 11,5, and the Product 0,5175 added to BQ makes 20,5175. Therefore I ſuppoſe ſecondly $BQ = 20{,}51$, and there will ariſe, in the ſame Manner as in the foregoing, $NP = 19{,}5092$; to which adding BN, the Sum is 20,5092, which is leſs than BQ. Wherefore if the Difference 0,0008 is multiplied by 11,5, and the Product 0,0092 is ſubtracted from BQ, there will remain $Bq = 20{,}5008$.

Laſtly, let the mean Motion be equal to 2°. I ſuppoſe BQ 30°, and there is found $NP = 27{,}84$; to which adding 2°, the Sum 29,84 is leſs than 30. And if the Difference 0,16 is multiplied by 6,3 (for L — Coſin. BQ is to L, as 1 to 6,3 nearly) it will be $1{,}008 = Qq$. Therefore this Arch ſubtracted from BQ gives $Bq = 28{,}982$. Now that Bq may be corrected, I aſſume (ſecondly) $BQ = 29$ Degrees; and by a like Proceſs we ſhall find $Bq = 28{,}9672$.

III. No

The Parallax of the Sun to be found, by ſeeing *Venus* between the Sun and the Earth. *by Dr.* E. Halley, n. 348. p. 454.

III. No Problem ſeems more difficult than that, of determining the Diſtance of the Sun from the Earth near to the Truth; which yet may be perform'd with no great Labour, by having certain accurate Obſervations, perform'd at choſen and foreſeen Times. This I ſhall lay before this Society in the preſent Diſſertation, that I may ſhew a Way how it may be done to our younger Aſtronomers, who may have an Opportunity of obſerving this; ſo that they ſhall be able to meaſure truly the immenſe Diſtance of the Sun, within the five hundredth Part of that Diſtance.

Now it is known, that by different Authors of Aſtronomy this Diſtance is variouſly ſuppoſed, as it ſeems probable by Conjecture to every one. By *Ptolomy* and his Followers, as alſo by *Copernicus* and *Tycho Brahe*, it is made a thouſand and two hundred Semidiameters of the Earth, and by *Kepler* nearly three thouſand five hundred. *Ricciolus* doubles the Diſtance of *Kepler*, which *Hevelius* only enlarges by one Half. But when the Planets *Venus* and *Mercury* are ſeen in the Diſk of the Sun by Means of a Teleſcope, and ſo ſtript of their borrow'd Splendor, it is at laſt found out, that the viſible Diameters of the Planets are much leſs than they were thought to be hitherto; and that the Semidiameter of *Venus* ſeen from the Sun does not ſubtend above a Quarter of a Minute. That the Semidiameter of *Mercury*, at its mean Diſtance from the Sun, is ſeen only under an Angle of ten Seconds; and that the Semidiameter of *Saturn* is ſeen from the Sun under the ſame Angle. That the Semidiameter of *Jupiter*, the greateſt of the Planets, does not ſubtend at the Sun an Angle of above a third Part of a Minute. Whence ſome of our modern Aſtronomers have been of Opinion, that keeping to the ſame Analogy, the Semidiameter of the Earth alſo, when ſeen from the Sun, ſubtends an Angle of an intermediate Magnitude, or greater than that of *Jupiter*, and leſs than that of *Saturn* and *Mercury*, being equal to that of *Venus*, or about 15 Seconds: And therefore the Sun is diſtant from the Earth near 14000 Semidiameters of the Earth. But with the ſame Authors another Argument has a little enlarged this Diſtance. For ſince the Diameter of the Moon is ſomething greater than a fourth Part of the Diameter of the Earth, if the Parallax of the Sun is ſuppoſed to be 15 Seconds, the Body of the Moon would become greater than the Body of *Mercury*. That is, a ſecondary Planet would be greater than a primary one; which would ſeem contrary to that Concinnity which ſhould obtain in the Syſtem of the World. And on the contrary, the ſame Concinnity will hardly allow, that *Venus* an inferior Planet, and deſtitute of Satellites, ſhould be greater than our Earth a ſuperior Planet, and attended with ſo remarkable a Companion. Therefore that we may keep a Medium, let the Semidiameter of the Earth ſeen from the Sun, or which is the ſame Thing, let the horizontal Parallax of the Sun be 12 Seconds and an Half; whence the Moon will be leſs than *Mercury*, and the Earth greater than *Venus*, and the Diſtance of the Sun from the Earth will come out 16500 Semidiameters of the Earth very near. Now at preſent I give my Aſſent to this Diſtance, till it may appear more certainly how great it is, by the Experiment I ſhall now propoſe. Nor am I ſwayed by the Authority of thoſe, who enlarge the Diſtance of the Sun immenſely beyond theſe Limits, relying upon the Obſervations of the Vibrations of a Pendulum, which cannot be truſted, (as I think) in determining ſuch minute Angles. Surely to any one that trys to find the Parallax this Way, ſometimes it will come, out nothing, ſometimes negative; that is, the Diſtance will be infinite or more than infinite, which is abſurd. Moreover, to diſtinguiſh certainly to Seconds, or even to ten Seconds, by Inſtruments never ſo artificially made, is hardly allow'd to mortal Man. And therefore it is not at all to be wonder'd at, if the great Subtilty of the Thing has hitherto eluded all the many and ingenious Attempts of the greateſt Aſtriſts.

But now almoſt 40 Years ago, when I was in the Iſland of St. *Helena*, where I was employ'd in Obſervations of the fixt Stars which ſurround the South Pole; I had an Opportunity of obſerving *Mercury* paſſing through the Disk of the Sun, which I did with the greateſt Diligence. I obtain'd moſt accurately, with an excellent Tube of 24 Feet, the Moment in which *Mercury* entring the Sun's Limb was ſeen to touch it within; and in like Manner, the Moment in which at going out he touch'd the Sun's Limb, making an Angle of inward Contact. Whence I was ſure of the Interval of Time, in which the whole Body of *Mercury* appeared at that Time within the Disk of the Sun, and that without an Error of one Second of Time. For the Thread of the Solar Light, intercepted between the obſcure Limb of the Planet and the bright Limb of the Sun, ſlender as it was, appear'd to ſtrike the Eye, and in ſtriking the Eye, the Denticle made in the Limb of the Sun by the Entrance of *Mercury*, vaniſh'd, as that made by his going out began as it were in a Moment. When this was known, I was immediately aſſured, that the Sun's Parallax might be truly determin'd from this Kind of Obſervations, if only *Mercury* being nearer the Earth ſhould have a greater Parallax from the Sun. For this Difference of Parallaxes is ſo very little, that it is always leſs than that of the Sun which we enquire after. Wherefore *Mercury*, tho' often to be ſeen within the Sun, will not be thought very proper for this Buſineſs.

There remains therefore the Tranſit of *Venus* through the Sun's Disk, whoſe Parallax, almoſt four Times as big as that of the Sun, will make very ſenſible Differences between the Spaces of Time, in which *Venus* will be ſeen to paſs over the Sun, in the different Regions of our Earth. Now from theſe Differences, if obſerved after a due Manner, I ſay the Parallax of the Sun may be determin'd within a ſmall Part of a Second. Nor are other Inſtruments required than Teleſcopes and common Clocks, but good ones; and in the Obſervations nothing is required but Fidelity and Diligence, with a moderate Skill in Aſtronomy. For there is no Neceſſity that the Latitude of the Place ſhould be determin'd with much Scrupuloſity, or that the Hours, in reſpect of the Meridian, ſhould be accurately determin'd. It will be ſufficient to have the Clocks well corrected to the Revolutions of the Heavens, and that the Times be reckoned from the total Ingreſs of *Venus* within the Sun's Disk, to the Beginning of its Egreſs from the ſame. That is, when firſt the opaque Globe of *Venus* begins to reach the lucid Limb of the Sun; which Moments, as I know by my own Experience, may be obſerved to a Second of Time.

But becauſe the Laws of Motion are greatly confined, *Venus* can be ſeen but very rarely within the Orb of the Sun; and for a Series of above 120 Years, it will not be ſeen there once: That is, from the Year 1639, (when our *Horrox* enjoy'd this Spectacle, who was the firſt and only one from the Creation of the World to this Day) to the Year 1761, *May* 26, in the Morning, when the Planet *Venus* will again paſs under the Sun, according to thoſe Theories which hitherto we have found to agree with the Heavens; ſo that at *London*, at about Six in the Morning, ſhe may be expected to be found in the Middle of the Sun's Disk, nor will ſhe be above four Minutes more Southerly than the Center of the Sun. And the Duration of this Tranſit will be nearly eight Hours, or from Two in the Morning to almoſt Ten. Therefore the Ingreſs will not be viſible in *England*. And whereas the Sun at that Time will be in 16 Degrees of *Gemini*, declining Notherly almoſt 23 Degrees; it may be ſeen not to ſet through the whole Northern frigid Zone. So that they which inhabit the Sea-ſhore of *Norway*, beyond the City *Nidroſia*, which they call *Dronthem*, as far as its Northern Promontory, may obſerve *Venus* at its entring upon the Sun's Disk. And perhaps that Ingreſs into the riſing Sun may be ſeen by the Northern *Scots*, and the Inhabitants of the Iſland of *Shetland*. Now at the Time that *Venus* will be neareſt to the Center of the Sun, the Sun will be vertical above the Northern Shores of the Bay of *Ganges*, or rather of the Kingdom of *Pegu*. And therefore in the adjacent Countries, as the Sun at the Ingreſs of *Venus* will be diſtant almoſt four Hours to the Eaſt, and at the Egreſs almoſt as much to the Weſt; the apparent Motion of *Venus* within the Sun will be accelerated by almoſt the double of the horizontal Parallax of *Venus* from the Sun; becauſe then *Venus* moves retrograde from Eaſt to Weſt, and at the ſame Time an Eye upon the Earth's Surface has a contrary Rotation from Weſt to Eaſt.

Now if the Sun's Parallax be ſuppoſed 12½ Seconds, the Parallax of *Venus* will be 43 Seconds. And taking away the Sun's Parallax, there will remain at leaſt Half a Minute for the horizontal Parallax of *Venus* from the Sun, and therefore the Motion of *Venus* will be advanced by that Parallax at leaſt three Quarters of a Minute, while it runs over the Sun's Disk; in thoſe Altitudes of the Pole as are near the Tropick, and ſtill more near the Equator. Now at that Time *Venus* will move four Minutes an Hour within the Sun pretty exactly, and therefore at leaſt eleven Minutes of Time belong to the three Quarters of a Minute, by which the Duration of this Eclipſe of *Venus* will be contracted becauſe

cauſe of the Parallax. And from this Contraction alone we might ſafely conclude about the Parallax we ſeek, if the Diameter of the Sun and the Latitude of *Venus* were given exactly; yet to poſtulate theſe for Computation, in a Matter ſo ſubtile as this is, is hardly allowable.

Therefore another Obſervation is to be provided, if it may be done in thoſe Places where *Venus* has Poſſeſſion of the Middle of the Sun at Midnight, or under the Meridian which is oppoſite to the former; that is, at a Place that is about 6 Hours or 90 Degrees more Weſterly than *London*, and where *Venus* enters the Sun a little before its Setting, and comes out a little after its Riſing. This will be in the ſaid Meridian under the North Pole's Altitude of about 56 Degrees: That is, in that called *Hudſon*'s Bay, at a Place call'd *Nelſon*'s Harbour. For in Places near this, the Parallax of *Venus* will protract the Duration of the Tranſit, and will make it at leaſt ſix Minutes longer; becauſe while the Sun ſeems under the Pole to proceed from Eaſt to Weſt, thoſe Places in the Disk of the Earth will ſeem to move with a contrary Motion towards the Weſt, that is, by a Motion conſpiring with the proper Motion of *Venus*. Therefore *Venus* will ſeem to move more ſlowly within the Sun, and to paſs over his Disk with more Delay.

If therefore it ſhould happen, that in each Place this Tranſit ſhould be obſerved by proper Obſervers, it is plain that the Mora to be obſerved in *Nelſon*'s Harbour would be full ſeventeen Minutes longer, than what is to be expected at the *Eaſt-Indies*. Neither is it much Matter whether the Obſervation be taken at Fort St. *George* commonly call'd *Maderas*, or at *Bencoulen* on the Weſtern Shore of the Iſland of *Sumatra* near the Equator, if the *Engliſh* at that Time ſhall be inclined to do it. Or if the *French* ſhall think fit to do it, the Obſerver will be conveniently ſituated at *Poudecherry*, on the Weſtern Shore of the *Sinus Gangeticus*, under the Altitude of the Pole about 12 Degrees. To the *Dutch*, their famous Emporium of *Batavia*, will ſupply an Obſervatory convenient enough, if they have a Mind to advance this Part of Aſtronomy. And indeed I could wiſh, that Obſervations of this Phænomenon might be made by ſeveral Obſervers in different Places, as well for the greater Confirmation of the ſame by their Agreement, as for Fear a ſingle Obſerver might be prevented by the Interpoſition of Clouds, and hinder'd from a Sight which I know not whether the Men of this and the following Generation will ever ſee again; and on which depends the certain and adequate Solution of a moſt noble Problem, which is not otherwiſe to be attain'd. Therefore we recommend again and again, to the curious Enquirers into Sydereal Affairs, to whom theſe Obſervations are reſerved, that being mindful of this our Admonition, they would apply themſelves ſtrenuouſly and with all their Power, to the due Performing this Obſervation; wiſhing them all proſperous Succeſs, and that the Magnitudes of the Celeſtial Orbs, being then determin'd within more exact Limits, may reward them with perpetual Fame and Glory.

Now we have affirm'd above, that by this Method the Parallax of the Sun may be diſcover'd within a five hundredth Part of its own Magnitude, which, without doubt, to ſome will ſeem wonderful. But if in both the

Places here mark'd out, an accurate Obſervation be made, we have already ſhew'd, that the Durations of theſe *Venereal* Eclipſes may differ from one another by full 17 Minutes, from the Hypotheſis that the Parallax of the Sun is 12 Seconds and an half. Now if this Difference be found by Obſervation to be either greater or leſs, the Parallax of the Sun will be greater or leſs almoſt in the ſame Proportion. And ſince 17 Minutes of Time correſpond to 12 ½ Seconds of the Solar Parallax, for every Second of Parallax will ariſe a Difference of above 80 Seconds of Time. Therefore if this Difference is had true and approved within two Seconds, it will appear within a fortieth Part of a Second how great the Sun's Parallax is. And therefore his Diſtance will be determined within a five hundredth Part of itſelf, at leaſt of its Parallax, ſhall be found not leſs than we have ſuppoſed it: For 40 Times 12 ½ make 500.

Hitherto I have explained the Matter enough, or perhaps more than enough, to Aſtronomers; whom I would alſo inform, that in this Argument I have took no Account of the Latitude of the Planet, as well to avoid the Trouble of an intricate Calculation, which would make the Concluſions leſs evident, as becauſe of the Motion of *Venus*'s Nodes not yet found out, nor to be truly determin'd but by ſuch corporal Conjunctions of the Planet with the Sun. For it is not concluded that *Venus* will paſs in four Minutes under the Sun's Center, but upon Suppoſition, that the Plain of *Venus*'s Orbit, immoveable in the Sphere of fixt Stars, will have its Nodes in the ſame Places where they were found in the Year 1639. Now if in the Year 1761, it ſhould paſs in a Path that is more Southerly, it will plainly appear that the Nodes go backwards; but if in a more Northerly, that they go forwards among the fix'd Stars; and that in the Ratio of 5 ½ Minutes in 100 *Julian* Years, for every Minute, in which the Path of *Venus* ſhall be diſtant at that Time more or leſs from the Sun's Center, than the ſaid four Minutes. But the Difference between the Durations of theſe Eclipſes will be a little leſs than 17 Minutes, becauſe of *Venus*'s South Latitude; but it will be greater, as the Nodes go on, if it paſſes the Sun to the North of its Center.

Now for the Sake of thoſe who delight in Celeſtial Obſervations, and yet have not imbibed the whole Doctrine of Parallaxes, I ſhall farther explain the Matter with a Scheme, and with a Calculation that is ſomething more accurate.

Let us ſuppoſe therefore, that in the Year 1761, *May* 25. 17^{h}. 55′. at *London*, the Sun will be in ♊ 15°. 37′. and therefore at its Center the Ecliptic will tend towards the North in an Angle of 60°. 10′. But at that Time the viſible Path of *Venus* within the Sun's Diſk will deſcend towards the South, making an Angle with the Ecliptic of 8°. 28′; therefore the Path of *Venus* will tend a little towards the South in reſpect to the Equator, interſecting the Parallels of Declination in an Angle of 2°. 18′. Let us alſo ſuppoſe, that at the ſame Time *Venus* is neareſt to the Center of the Sun, and is diſtant from the ſame towards the South four Minutes; and that every Hour with a retrograde Motion it runs four Minutes within the Sun. But

the

ig. 218.

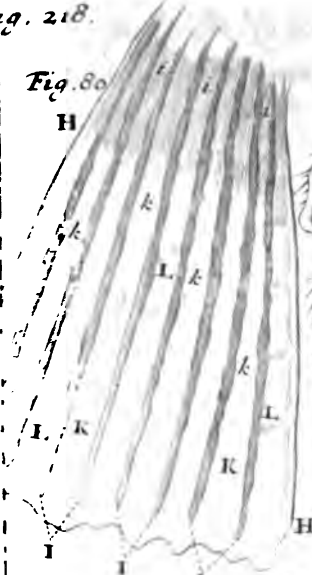


Fig. 80

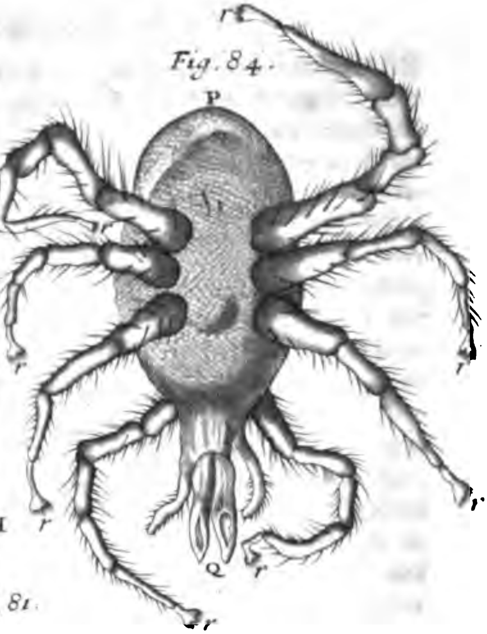


Fig. 84.

Fig 81

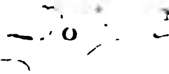
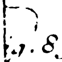


Fig. 82.


ı. 83

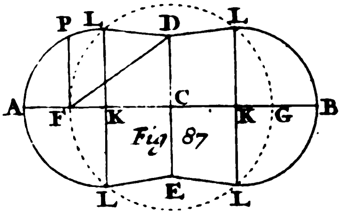


Fig 87

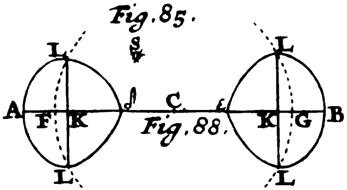


Fig. 85.

Fig. 88.

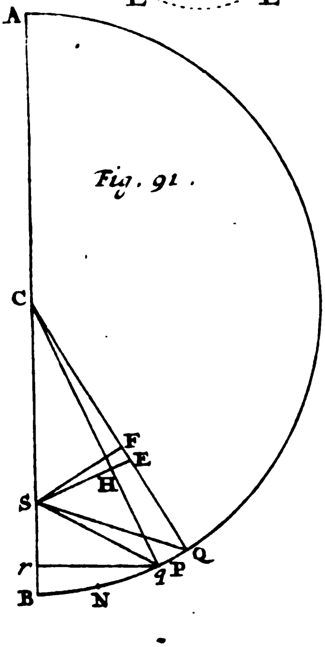


Fig. 91.

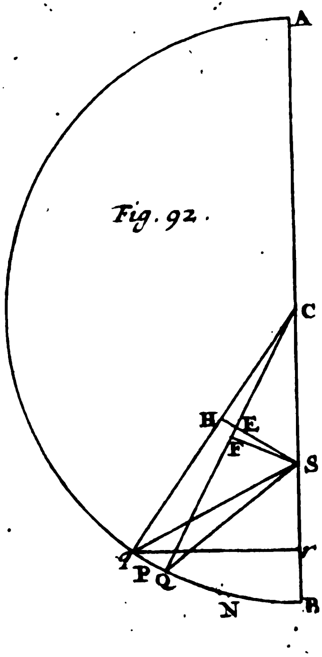


Fig. 92.

the Sun's Semidiameter will be nearly 15′. 51″, and that of *Venus* 0′. 37″ ½. And let us ſuppoſe for Experiment Sake, that the Difference of the horizontal Parallaxes of *Venus* and the Sun, which we are enquiring for, to be 0′. 31″, as is derived from ſuppoſing the Sun's Parallax to be 0′. 12″ ½. Therefore with Center *C* let a little Circle *AEBD* be deſcribed, whoſe Semidiameter is 0′. 31″. repreſenting the Diſk of the Earth, and in it the Ellipſes of the Parallels of 22 and 56 Degrees, North Latitude, in a Manner now uſed by Aſtronomers for the Conſtruction of Solar Eclipſes, at *DabE*, *cde*: And let *BCA* be the Meridian in which the Sun is, to which let the right Line *FHG*, denoting the Path of *Venus*, be inclined in an Angle of 2°. 18′, whoſe Diſtance from the Center *C* is 240 ſuch Parts as *BC* is 31; and from *C* let fall the right Line *CH* perpendicular to *FG*. And ſuppoſing the Planet in *H* at 17^{h}. 55′, or 5^{h}. 55′ in the Morning, let the right Line *FHG* be divided into the Horary Spaces III. IV, IV. V, V. VI, *&c.* equal to *CH*, that is to four Minutes. Alſo make the right Line *KL* equal to the Difference of the apparent Semidiameters of the Sun and *Venus*, or 15′. 13″ ½. And a Circle deſcribed with Radius *KL*, and its Center any Point within the little Circle of the Earth's Diſk, will meet the right Line *FG* in a Point denoting the Hour which will be reckoned at *London*, when *Venus* with its Angle of Contact ſhall touch the Limb of the Sun within, in that Place of the Earth's Surface which lies under the Point aſſumed in the Diſk. But if the Circle deſcribed with Center *C* and Radius *KL* ſhould meet *FG* in the Points *F* and *G*, the right Lines *FH*, *HG* = 14′, 41″, which *Venus* will ſeem to paſs over in 3 Hours and 40 Minutes. Therefore *F* will fall in 2^{h}. 15′, at *London*; and *G* in 9^{h}. 35′, in the Morning. Whence it appears, that if the Magnitude of the Earth ſhould vaniſh as it were into a Point, becauſe of its immenſe Diſtance, or if deprived of its diurnal Motion, it ſhould have the Sun always vertical to the ſame Point *C*, the entire Mora of this Eclipſe would continue for 7 ⅓ Hours. But as the Earth revolves in the mean Time with a Motion contrary to that of *Venus* through 110 Degrees of its own Longitude, and therefore the Duration of the ſaid Mora being contracted, ſuppoſe 12 Minutes, it will come out 7^{h}. 8′ nearly, or 107 Degrees. Fig. 93.

Now in the Meridian itſelf *Venus* will be next the Center of the Sun, at the Eaſtern Mouth of the River *Ganges*, where the Altitude of the Pole is about 22 Degrees. Therefore that Place will be equally diſtant from the Sun on each Side, at the Moments of Ingreſs and Egreſs of the Planet, that is at 53° ½, as the Points *a* and *b* are in the greater Parallel *DabE*. But the Diameter *AB* will be to the Diſtance *ab*, as the Square of the Radius is to the Rectangle under the Sines of 53° ½ and 68°, that is, as 1′. 02″. to 0′. 46″. 13‴. And when the Calculation is rightly perform'd, (which I omit that I may not be tedious) I find that the Circle deſcribed with Center *a* and Radius *KL*, will meet the right Line *FH* in the Point *M*, at 2^{h}. 20′. 40″; but when deſcribed with Center *b*, it will meet *HG* in *N*, at 9^{h}. 29′. 22″: That is, if the Hours are reckon'd at *London*. Therefore all *Venus* will be ſeen within the Sun upon the Banks of the *Ganges*, for 7^{h}. 8′. 42″.

Therefore we have rightly ſuppoſed its Duration will be $7^h. 8'$, ſince here a Part of a Minute is of no Conſideration.

Now the Calculation being adapted to *Nelſon*'s Harbour, I find that *Venus* will enter the Sun's Disk when it is ready to ſet; and that it will come out of the ſame preſently after its Riſing. In the mean Time that Place will be transfer'd from *c* to *d* through the Hemiſphere oppoſite to the Sun, with a Motion conſpiring with the Motion of *Venus*. Therefore the Mora of *Venus* within the Sun will be longer becauſe of the Parallax, perhaps by four Minutes, that it may be full $7^h. 24'$, or 111 Degrees of the Equator. And ſince the Latitude of the Place is 56 Degrees, it will be as the Square of the Radius to the Rectangle under the Sines of $55\frac{1}{2}$ and 34 Degrees, ſo in *AB* or $1'. 02''$ to *cd* or $28''. 33'''$. And when the Calculation is rightly perform'd it will appear, that a Circle deſcribed with Center *c* and Radius *KL*, will meet *FH* in *O*, at $2^h. 12'. 45''$; but deſcribed with Center *d*, it will meet *HG* in *P*, at $9^h. 36'. 37''$. Whence the Duration of the Mora at *Nelſon*'s Harbour will be $7^h. 23'. 52''$, that is greater than at the Mouth of the *Ganges* by $15'. 10''$, of Time. Now if *Venus* ſhould paſs without Latitude, the ſaid Difference would be $18'. 40''$; and if it ſhould be 4 Minutes more Northerly than the Center of the Sun, the ſame Difference will be increaſed to $21'. 40''$; and it would be much greater, if the Planets Northern Latitude ſhould be greater.

Now it follows from the aforeſaid Suppoſitions, that at *London Venus* will riſe after it has enter'd within the Sun; and that at $9^h. 37'$. in the Morning it will touch the inward Limb of the Sun at its Egreſs; and laſtly, that it will not leave its Orb entirely till $9^h. 56'$.

From the ſame Suppoſitions it follows alſo, that in the Year 1769, *May* 23, at $11^h. 00'$. the Center of *Venus* muſt skim by the utmoſt Northern Limb of the Sun; ſo that, becauſe of the Parallax, it may wholly appear not to immerge in the Sun, in the Northern Parts of *Norway*; whilſt upon the Shores of *Peru* and *Chili* it will be ſeen as it were riding upon the Disk of the ſetting Sun, with a very ſmall Segment immerſed: As in the *Molucca* Iſlands and the neighbouring Places, on the Disk of the riſing Sun. Now if the Nodes of *Venus* are found to go backwards, (as is ſuſpected becauſe of ſome late Obſervations) then being every where conſpicuous with its whole Body within the Orb of the Sun, by the very great Difference of theſe Eclipſes, it will ſupply a much more convincing Argument of the Sun's Parallax.

But how from Obſervations made ſomewhere in the *Eaſt-Indies*, An. 1761, of the Ingreſs and Egreſs of *Venus*, and compared with Obſervations of the Exit made here, the ſame Parallax may be ſettled, by adapting the Angles of a Triangle given in Species to the Circumferences of three equal Circles, ſhall be ſhewn upon another Occaſion.

Of the Maxima *and* Minima *in the Motions of the* Celeſtial *Bodies, by*—— n. 360. p. 948.

IV. The Theory we now receive is owing to *Kepler*, that the Heavenly Bodies ſurround the Sun, placed in the common Focus of the Elliptical Orbits, on this Condition, that by Lines drawn to the Sun, they deſcribe Areas which are proportional to the Times of Deſcription. But it requires the moſt ſublime Geometry to ſhew, by what Cauſe this is perform'd, and that it could not be otherwiſe. This was reſerved to be the Glory of the famous *Newton*.

Treading in his Steps, that excellent Mathematician Mr. *A. de Moivre*, F. R. S. has deliver'd certain Corollaries mentioned before, which are ready Theorems by which the Velocities or Moments both of real and apparent Motion about the Sun are determin'd, as alſo of the Approach or Receſs to or from the Sun, in any given Points of given Orbits. Then farther to improve the Theory of the Planetary Syſtem, he has enquired after the Moments of the ſaid Moments by Means of the ſame Theorems, and ſhews in what Points of the Orbits are the greateſt Changes of theſe Velocities, and this by Solutions that excel in Neatneſs and Facility. *Vid.* ſupra, C. I. S. I.

Let ABP be the Elliptical Orbit of a Planet, AP the Tranſverſe Axis, CB the Conjugate Semiaxis, S the Sun, Q the other Focus of the Ellipſis. Through S draw SM parallel to CB; and the Point M will be that in which the Diſtance from the Sun is increaſed or diminiſhed with the greateſt Velocity, $SM = AC - \frac{SC}{AC}$. Fig. 94.

But if SL is taken a mean Proportional between the Semiaxes AC, CB, the Point L will be that in which there will be the greateſt Equation of the Center, as they call it, or where the Angular Motion is equal to the mean Motion. Now if the Eccentricity does not exceed that which moſt of the Planets obtain, it will be $BL = \frac{1}{4} BM$ very nearly. For it is $SL = \sqrt{ACqq - ACq\,SCq}$.

If the Point N be required in which is the greateſt Change of Velocity of the real Motion in the Curve, the Problem will be ſolid. For it is $2\,NS = 4AC - 2\,NQ$ to $3\,NQ - AC$, as $ACq - CSq = CBq$ to NQq. And therefore if we make $AC = a$, $BC = c$, and $NQ = y$, we ſhall have the Equation $y^3 - 2\,ay^2 + \frac{1}{2}ccy - \frac{1}{2}acc = 0$, which being reſolved y or NQ will be the Diſtance of the Point ſought N from the other Focus of the Ellipſis. But in Orbits that are but little excentric, ſuch as thoſe of the Planets, if it be made $CD = Sq$, and joining AD if AK be made equal to it, the remaining Part of the Axis $KP = NS$ will be the Diſtance of the Point N from the Sun very nearly. But if the Orbit be parabolical, SN will be to SP, as 5 to 4, and the Angle NSP will be 53°. 8′, nearly, whoſe Sine is $\frac{4}{5}$ of the Radius.

But the Point O, in which is the greateſt Acceleration of the apparent or angular Motion of the deſcending Planet, or the greateſt Retardation of the aſcending, will be had in this Manner. In AC let there be taken $GC = \frac{1}{8} AC$, and let CSF be made an Angle of 30 Degrees, and drawing SF let CE be made equal to it, and let GH be made equal to GE. I ſay, that if the Diſtance SO be made equal to PH, that in the Point O will be the greateſt Change of the Angular Motion of the Planet moving in the Elliptical Orbit $ABOP$; for in that Place of the Orbit the ſecond Differences of the Equations of the Center of the Planet will be found the greateſt. But it is $SQ = \frac{7}{6} AC - \sqrt{\frac{1}{36} ACq + \frac{1}{3} SQq}$. Now if the Orbit is Parabolical, as in the Comets, it will be $SO . SP :: 8 . 7$, and the Angle OSP will be $41^\circ . 24' \frac{1}{2}$, or whoſe Sine is to Radius as $\sqrt{7}$ to 4.

Laſtly, The Direction of the Tangent of the Orbit will be changed with the leaſt Velocity in *R*, if SR be made equal to two third Parts of the greater Axis AB. But if the Eccentricity SC is leſs than $\frac{1}{3} PC$, this Minimum does not take Place, but this Velocity with which the Tangent revolves is always decreaſing, as far as the Aphelium itſelf, as it is in the Motions of all the Planets. But it does not obtain in a Parabolical Orbit, becauſe of its Axis continued *in infinitum*.

All theſe Things are demonſtrated from the foregoing Theorems of Mr. *Abr. Demoivre*, according to the Precepts of the Doctrine *de Maximis et Minimis*.

A new Star in the Swan's Neck, *by Mr.* G. *Kirch*, n. 343.p.226 *Miſcel. Berol.* p. 208.

V. Though many Varieties and Changes happen in the Heavens, among the fixt Stars, as to their apparent Magnitude, yet among all the mutable Appearances of the fixt Stars none is more wonderful, than that which *Fabricius* firſt obſerved *Ann.* 1596, in the *Whale's Neck*. For though at firſt it was accounted as ſuch a new Star as had no Exiſtence before, and after it had diſappear'd that it would return no more; yet now Experience has ſufficiently proved that it conſtantly exiſts, and that without all doubt it has always exiſted from the Beginning of the World in that Place, which it ſtill poſſeſſes. This only is wonderful in it, that it ſhews itſelf yearly of a different Magnitude, and generally at certain Times it is not at all to be ſeen by the naked Eye. For this Reaſon it is call'd by *Hevelius* the wonderful Star.

Like to this I have alſo found another in the *Swan's Neck*, but much leſs, and which may be ſeen yearly for a ſhorter Space of Time. Therefore it is no wonder that it has ſo long continued unknown. Nay, it is to be conſider'd as a ſingular Felicity, that it was viſible at that very Time, and appear'd in its greateſt Magnitude, when *Bayer* contemplated and delineated the Stars in the *Swan*, where he denoted it by the Character χ, and reckon'd it among the Stars of the fifth Magnitude which conſtantly appear. As alſo the above-mention'd Star in the *Whale's Neck*, when he conſider'd and delineated this Conſtellation, he found it of the fourth Magnitude, and mark'd it with the Letter *o*, and look'd upon it as a Star that always appears.

Fig. 95.

To find out the mutable Appearance of the Star χ in the *Swan's Neck*, Occaſion was given by a neighbouring Star in the *Swan's Head*, which *Hevelius* obſerv'd *Ann.* 1670, and 1671. For when I had entertained ſome Hope, that the ſame Star would often appear again, not otherwiſe than the Star in the *Whale's Neck*, which after its firſt Diſappearance would ſoon appear again, as was evident to *Hevelius*; I ſought for it on the *1ſt* and *6th* of *July* (or 11° and 16°) in the Year 1686 in clear Nights, but could not find it. I rather took Notice, that that Star of the fifth Magnitude in the Neck of the Swan was wanting, which *Bayer* marks with the Greek

Letter χ. But on the 9*th* (19) Day of *October*, I found it very plainly with my naked Eye. And becauſe I was eaſily perſuaded to think, that it might again diſappear to my naked Eye, I delineated ſome Stars that ſtood round it, by the Help of a two Foot Teleſcope of large Capacity, that by a Compariſon of theſe with it I might examine its Magnitude when it decreaſed, as is repreſented in the Figure *A*.

I alſo found, that that Star decreaſed by little and little, till I could no longer perceive it with a Tube of eight Feet; whereas I could always diſtinguiſh another in the *Whale's Neck*, through a Tube of four Feet, when it could no longer be perceived with the naked Eye. Fig. 96.

From that Time I ſought in vain for that Star ſeveral Nights together, yet at laſt I found it again, *Auguſt* 6, (16) 1687, by Help of an eight Foot Tube, though it was very ſmall. From thence I obſerved it to increaſe daily; and it happen'd that *Oct.* 23, (*Nov.* 2,) it firſt preſented itſelf to my naked Eye, though ſtill very ſmall. On the 2*d* Day of *November*, (12°) it was very conſpicuous, and even after *Nov.* 26, (*Dec.* 6,) though on this laſt Day it was again in a State of Decreaſe. Afterwards it could not be diſtinguiſh'd but by the Tubes, and ſoon became ſo ſmall, that I could not find it again with the eight Foot Tube. And thus it was obſerved, that from one Diſappearance to another, there paſs'd about one Year, one Month, and one Week. Alſo the following Obſervations have inform'd me, that this Star kept a pretty conſtant Time in its Appearance, yet at every Period it did not arrive at an equal Magnitude. Nay it happen'd ſometimes, that it continued altogether inviſible to the naked Eye, whilſt through the Tube it was conſpicuous, and increaſed to its greateſt Magnitude. As at the End of the Year 1688, and the Beginning of 1689. On the contrary, in the Year 1690, this Star could be ſeen better, and was notably greater than its Neighbour, which *Bayer* has placed near χ, without the *Swan's Neck*, but has mark'd it with no Letter; but only for the Help of my Memory I have mark'd it with the *Hebrew* Letter ג. And after I had often obſerved the Appearance of this Star, I found it to be very regular, and to obſerve the Revolution of 404½ Days.

N. B. *Whereas the* Berlin *Miſcellanies come late to our Hands, we did not obſerve this new Star, which Mr.* Kirch *has inform'd us of, before the Year laſt paſt, and that near the Ides of* July, *ſt. vet. when it appear'd much brighter than the neighbouring Star* ג, *and almoſt equal to the middle Star in the* Swan's Neck, *mark'd by* Bayer η. *But becoming inconſpicuous to the naked Eye, at laſt it vaniſh'd alſo in the Teleſcope. According to the Period in which it is ſaid to revolve, it muſt have arriv'd at its greateſt Brightneſs at leaſt in the Month of* Auguſt *of the current Year* 1715.

Now that it may be found more eaſily in the Heaven, we have added two Schemes, one of which ſhews the Swan's Neck, *with the Stars adjoining to this new one, and with two other new ones that have appear'd near it within this laſt Age; of which that before the* Swan's Breaſt *is ſtill to be ſeen as it were of the fifth Magnitude. But that which is under the Head was ſeen only for two Years, and now diſappears. The other Figure, which is Mr.* Kirch's Fig. 95, 96.

A; *ſhews the Teleſcupick Stars which are near the new one, that it may be known in what Place exactly it may be look'd for, and where the diligent Obſervers of the Heavens, aſſiſted by their Tubes, may expect its firſt Ray at its Return.*

A Hiſtory of the new *Stars for the laſt* 150 *Years, by* .... n. 346. p. 354.

IV. Although it be ſaid that *Hipparchus*, on Occaſion of a new Star that appeared in his Time, was induced to number the Stars, and make the firſt Catalogue of them, which was, in the Opinion of *Pliny*, *a raſh Thing to be attempted even by a God*; yet neither he nor any of the Ancients have left us the Place of that new Star, to compare with thoſe lately ſeen, one of which might perhaps be the ſame with it, re-appearing after a long Period of Years. Now though ſeveral Authors have ſeverally deſcribed thoſe that have been ſeen nearer to our Times, it may not be amiſs to give a ſhort Recapitulation of what was principally remarkable in each of them, with the Times of their firſt Appearance, as far as can be collected.

And firſt, That in the *Chair* of *Caſſiopeia* was not ſeen by *Cornelius Gemma* on the 8th of of *November* 1572, who ſays, he that Night conſidered that Part of Heaven in a very ſerene Sky, and ſaw it not; but that the next Night, *November* 9°, it appeared with a Splendour exceeding all the fixt Stars, and ſcarce leſs bright than *Venus*. This was not ſeen by *Tycho Brahe* before the 11th of the ſame Month, but from thence he aſſures us, that it gradually decreaſed and died away, ſo as in *March* 1574, after ſixteen Months, to be no longer viſible; and at this Day not the leaſt Signs of it remain. The Place thereof, in the Sphere of fixt Stars, by the accurate Obſervations of the ſame *Tycho*, was 0^{s}. 9°. 17′. *à* 1ma ∗ ♈^{is}, with 53°. 45′. North Latitude.

Such another Star was ſeen and obſerved by the Scholars of *Kepler*, to begin to appear on *Sept.* 30°. *ſt. vet. anno* 1640, which was not to be ſeen the Day before; but it broke out at once with a Luſtre greater than that of *Jupiter*; and like the former it died away gradually, and in much about the ſame Time diſappear'd totally, there remaining no Footſteps thereof in *January* 160$\frac{5}{6}$. This was near the Ecliptick, following the Right Leg of *Serpentarius*; and by the Obſervations of *Kepler* and others, was in 7^{s}. 20°. 00′ à 1ma ∗. ♈, with North Latitude 1°. 56′. Theſe two ſeem to be of a diſtinct *Species* from the reſt, and nothing like them has appear'd ſince.

In the Year 1596, we have the firſt Account of the wonderful Star *in Collo Ceti*, ſeen by *David Fabricius* on the 3d of *Auguſt*, *ſt. vet.* as bright as a Star of the third Magnitude, which has been ſince found to appear and diſappear periodically; its Period being preciſely enough 7 Revolutions in ſix Years, though it return not always with the ſame Luſtre. Nor is it ever entirely extinguiſhed, but may at all Times be ſeen with a Six-foot Tube. This was ſingular in its Kind, till that in *Collo Cygni* was diſcovered. It precedes the firſt Star of *Aries* 1°. 40′, with 15°. 57′ South Latitude.

Another new Star was firſt obſerved by *Will. Janſonius* in 1600, *in Pectore* or rather *in eductione Colli Cygni*, which exceeded not the third Magnitude. This Star having continued ſome Years, became at length ſo ſmall, as to be thought by ſome to diſappear entirely; but in the Years 1657, 58, and 59, it again aroſe to the third Magnitude, though ſoon after it decayed by Degrees to the fifth or ſixth Magnitude, and at this Day is to be ſeen as ſuch in 9^{s}. 18°. 38′. *à* 1ma *. ♈, with 55°. 29′. North Latitude.

A fifth new Star was firſt obſerved by *Hevelius* in 1670, on *July* 15, *ſt. vet.* as a Star of the third Magnitude, but by the Beginning of *October* was ſcarce to be perceived by the naked Eye. In *April* following it was again as bright as before, or rather greater than of the third Magnitude, yet wholly diſappeared about the Middle of *Auguſt*. The next Year, in *March* 1672, it was ſeen again, not exceeding the ſixth Magnitude; ſince when it has been no farther viſible, though we have frequently ſought for its Return; its Place is 9^{s}. 3°. 17′. *à* 1ma *. ♈. and has Lat. North 47°. 28′.

The ſixth and laſt is that we deſcribed before from the *Acta Berolinenſia*, diſcovered by Mr. G. *Kirch* in the Year 1686, and its Period determined to be of 404$\frac{1}{2}$ Days; and though it rarely exceed the fifth Magnitude, yet is it very regular in its Returns, as we have found in the Year 1714. Since then we have endeavoured, as the Abſence of the Moon and the Clearneſs of Weather would permit, to catch the firſt Beginning of its Appearance in a ſix-foot Tube, that bearing a very great Aperture diſcovers moſt minute Stars. And on *June* 15. laſt, it was firſt perceived like one of the very leaſt Teleſcopical Stars; but in the reſt of that Month and *July* it gradually increaſed, ſo as to become in *Auguſt* viſible to the naked Eye; and ſo it continued all the Month of *September*. After that it again died away gradually, and on the 8*th* of *December* at Night was ſcarce diſcernible by the Tube, and as near as could be gueſſed, equal to what it was at its firſt Appearance on *June* the 15*th*; ſo that this Year it has been ſeen in all near ſix Months, which is but little leſs than half its Period; and the Middle, and conſequently the greateſt Brightneſs, falls about the 10*th* of *September*. Thoſe that pleaſe to ſeek for it, may expect its firſt Appearance in *July* next, and find it in 9^{s}. 6°. 30′. *circiter à* 1ma *. ♈, with *Lat. Bor.* 52°. 40′.

A Return of the new *Star in* Collo Cygni.

Vid. ſupra. §. V.

VII. Wonderful are certain luminous Spots or Patches, which diſcover themſelves only by the Teleſcope, and appear to the naked Eye like ſmall fixt Stars; but in Reality are nothing elſe but the Light coming from an extraordinary great Space in the Æther; through which a lucid *Medium* is diffuſed, that ſhines with its own proper Luſtre. This ſeems fully to reconcile that Difficulty which ſome have raiſed againſt the Deſcription *Moſes* gives of the Creation, alledging that Light could not be created without the Sun. But in the following Inſtances the contrary is manifeſt; for ſome of theſe bright Spots diſcover no Sign of a Star in the Middle of them; and the irregular Form of thoſe that have, ſhews them not to proceed from the Illumination of a central Body. Theſe are ſix in Number, all which we will deſcribe in the Order of Time, as they were diſcovered, giving alſo their Places in the Sphere of fixt Stars.

Lucid Spots or Nebulæ, *amongſt the fixt Stars, by* —— n. 347. p. 390.

The firſt and moſt conſiderable is that in the Middle of *Orion*'s Sword, marked with θ by *Bayer* in his *Uranometria*, as a ſingle Star of the third Magnitude; and is ſo accounted by *Ptolemy*, *Tycho Brahe* and *Hevelius*; but is in Reality two very contiguous Stars environed with a very large tranſparent bright Spot, through which they appear with ſeveral others. Theſe are curiouſly deſcribed by *Hugenius* in his *Syſtema Saturnium*, pag. 8. who there calls this Brightneſs, a monſtrous Thing, the like of which he could no where obſerve among the other fixt Stars; affirming that he found it accidentally in the Year 1656. The Middle of this is at preſent in ♊ 19°. 00′, with South Lat. 28° ¾.

About the Year 1661, another of this Sort was diſcovered (if I miſtake not) by *Bullialdus*, in *Andromeda*'s *Girdle.* This is neither in *Tycho* nor *Bayer*, having been omitted, as are many others, becauſe of its Smallneſs: But it is inſerted into the Catalogue of *Hevelius*, who has improperly called it *Nebuloſa* inſtead of *Nebula*; it has no Sign of a Star in it, but appears like a pale Cloud, and ſeems to ſend forth a radiant Beam into the North Eaſt, as that in *Orion* does into the South Eaſt. It proceeds in Right Aſcenſion the Northern in the Girdle, or ν *Bayero*, about a Degree and three Quarters, and has Longitude at this Time ♈. 24°. 00′ with Lat. North 33°⅓.

The third is near the Ecliptick between the *Head* and *Bow* of *Sagittary*, not far from the Point of the Winter Solſtice. This was found in the Year 1665, by a *German* Gentleman *M. J. Abraham Ihle*, while he attended the Motion of *Saturn* then near his *Aphelion.* This is ſmall but very luminous, and emits a Ray like the former. Its Place at this Time is ♑ 4°½ with about half a Degree South Lat.

A fourth was diſcover'd by M. *Edmund Halley* in the Year 1677, when he was making the Catalogue of the Southern Stars. It is in the *Centaur*, that which *Ptolemy* calls the Star in the Excreſcence on the Back, which he names the Cloud on the Horſe's Back, and is *Bayer*'s ω; It is in Appearance between the fourth and fifth Magnitude, and emits but a ſmall Light for its Breadth, and is without a radiant Beam; this never riſes in *England*, but at this Time its Place is ♏ 5°¾ with 35°⅓ South Latitude.

A fifth was diſcovered by Mr. *G. Kirch* in 1681, preceding the Right Foot of *Antinous:* It is of itſelf but a ſmall obſcure Spot, but has a Star that ſhines through it, which makes it more bright. The Longitude of this is at preſent ♑. 9°. *circiter*, with 17°⅙. North Latitude.

The ſixth and laſt was accidentally hit upon by M. *Edmund Halley* in the Conſtellation of *Hercules*, in the Year 1714. It is nearly in a Right Line with ζ and η of *Bayer*, ſomewhat nearer to ζ than η: and by comparing its Situation among the Stars, its Place is ſufficiently near in ♏ 26°½. with 57°. 00. North Lat. This is but a little Patch, but it ſhews itſelf to the naked Eye, when the Sky is clear, and the Moon abſent.

There are undoubtedly more of theſe, which have not yet come to our Knowledge, and ſome perhaps bigger, but though all theſe Spots are in Appearance but ſmall, and moſt of them but of few Minutes in Diameter; yet ſince they are among the fixt Stars, that is, ſince they have no annual Parallax, they cannot fail to occupy Spaces immenſely great, and perhaps not leſs than our whole Solar Syſtem. In all theſe ſo vaſt Spaces it ſhould ſeem, that there is a perpetual uninterrupted Day, which may furniſh Matter of Speculation, as well to the curious Naturaliſt as to the Aſtronomer.

VIII.

Change *of the* Latitudes *of ſome of the* fixt Stars, *by Dr.* E. Halley, n. 355. p. 736.

VIII. I have compared the Declinations of the fixt Stars delivered by *Ptolemy*, in the 3^d^ Chapter of the 7^th^ Book of his *Almag.* as obſerved by *Timocharis* and *Ariſtyllus* near 300 Years before *Chriſt*, and by *Hipparchus* about 170 Years after them, that is about 130 Years before *Chriſt*, with what we now find, and by the Reſult of many Calculations, I concluded that the fixt Stars in 1800 Years were advanced ſomewhat more than 25 Degrees in Longitude, or that the Preceſſion is ſomewhat more than 50″ *per annum*. But that with ſo much Uncertainty, becauſe of the imperfect Obſervations of the Ancients, that I have choſen in my Tables to adhere to the even Proportion of five Minutes in ſix Years, which from other Principles we are aſſured is very near the Truth. But while I was upon this Enquiry, I was ſurprized to find the Latitudes of three of the principal Stars in the Heaven directly to contradict the ſuppoſed greater *Obliquity* of the *Ecliptick*, which ſeems confirmed by the Latitudes of moſt of the reſt; they being ſet down in the old Catalogue, as if the Plane of the Earth's Orb had changed its Situation, among the fixt Stars, about 20′ ſince the Time of *Hipparchus*. Particularly all the Stars in *Gemini* are put down, thoſe to the *Northward* of the Ecliptick with ſo much leſs Latitude than we find, and thoſe to the *Southward* with ſo much more *Southerly* Latitude. And yet the three Stars *Palilicium* or the *Bull's* Eye, *Sirius* and *Arcturus* do contradict this Rule; for by it, *Palilicium*, being in the Days of *Hipparchus* in about 10 *gr.* of *Taurus*, ought to be about 15 Min. more *Southerly* than at preſent; and *Sirius* being then in about 15 of *Gemini* ought to be 20 Min. more *Southerly* than now; yet *Ptolemy* places the firſt 20 Min. and the other 22 more *Northerly* in Latitude than we now find them. Nor are theſe the Erors of Tranſcribers, but are proved to be right by the Declinations of them ſet down by *Ptolemy*, as obſerved by *Timocharis*, *Hipparchus* and himſelf, which ſhew that thoſe Latitudes are the ſame as thoſe Authors intended. As to *Arcturus*, he is too near the Equinoctial Colure, to argue from him concerning the Change of the Obliquity of the Ecliptick, but *Ptolemy* gives him 33′ more *North* Latitude than he now is found to have; and that greater Latitude is likewiſe confirmed by the Declinations delivered by the abovesaid Obſervers. So then theſe three Stars are found to be above half a Degree more *Southerly* at this Time, than the Ancients reckoned them. When on the contrary at the ſame Time the bright Shoulder of *Orion* has in *Ptolemy* almoſt a Degree more *Southerly* Latitude than at preſent. What ſhall we ſay then? It is ſcarce to be believed, that the Ancients could be deceived in ſo plain a Matter, three Obſervers confirming each other. Again, theſe Stars being the moſt conſpicuous in Heaven, are in all Probability the neareſt to the Earth; and if they have any particular Motion of their own, it is moſt likely to be perceived in them, which in ſo long a Time as 1800 Years may ſhew itſelf by the Alteration of their Places, though it be intirely imperceptible in the Space of one ſingle Century of Years. Yet as to *Sirius* it may be obſerved, that *Tycho Brahe* makes him 2 Min. more *Northerly* than we now find him, whereas he ought to be above as much more *Southerly* from his Ecliptick, (whoſe Obliquity he makes

makes $2\frac{1}{2}$ greater than we eſteem it at preſent) differing in the whole $4\frac{1}{2}$ Min. One half of this Difference may perhaps be excuſed, if Refraction were not allowed in this Caſe by *Tycho* ; yet two Minutes, in ſuch a Star as *Sirius*, is ſomewhat too much for him to be miſtaken.

But a more evident Proof of this Change is drawn from the Obſervation of the Application of the Moon to *Palilicium*, *Anno Chriſti* 509. *Mart.* 11°. when in the Beginning of the Night the Moon was ſeen to follow that Star very near, and ſeemed to have eclipſed it, ἐπέβαλλε γὰρ ὁ ἀϛὴρ τῷ παρὰ τὴν διχοτομίαν μέρει τῆς κύρης περιφερείας τȣ͂ πεφωτισμένȣ μέρȣς, *i. e.* the Star was apply'd to that Part, by which the illuminated Limb of the Moon was biſected. Now, from the undoubted Principles of Aſtronomy, this could never be true at *Athens*, near it, unleſs the Latitude of *Palilicium* were much leſs than we at this Time find it. *Vide Bullialdi Aſtr. Philolaica*, pag. 172.

This Argument ſeems not unworthy of the *Royal Society*'s Conſideration, to whom I offer the plain Fact as I find it, and would be glad to have their Opinion.

But whether it were really true, that the Obliquity of the Ecliptick was, in the Time of *Hipparchus* and *Ptolemy*, really 22 Min. greater than now, may well be queſtioned ; ſince *Pappus Alexandrinus*, who lived but about 200 Years after *Ptolemy*, makes it the very ſame that we do. *Vide Pappi Collect. Lib.* VI. *Prop.* 35.

Mock-Suns, *and Circular Arches, ſeen by Mr.* E. Halley, n. 278. p. 1127. Fig. 97.

IX. On the 8*th* of *April* 1702, walking in *London* Streets about Ten in the Morning, the Air being clear, I obſerved the Sun to ſhine faintly, or as we call it wateriſh ; whereupon caſting up my Eye, I perceived ſeveral Arches of Circles about him. I made what Haſte I could to get on the Top of a Houſe, which I did at Mr. *Mordens* by the *Royal-Exchange*, and found the Appearance as is deſcribed *Figure* 97, wherein

S is the true Sun, *Z* the Zenith.

S T P P a great wide Circle paſſing through the Sun, and as well as I could judge, parallel to the Horizon. It was very diſtinct and entire, about two Degrees broad in the *Northern* Part about *T* ; and held much the ſame Breadth in the *Eaſt* and *Weſt*, but grew narrower towards the Sun ; its Edges were not very well defined, the whole appearing like a faint white Cloud, and a Part of it would have been taken for ſuch, but the whole Circle ſeen in the pure Azure Sky was a very ſurprizing Sight.

V N X Y a *Halo*, or rather *Iris*, that was likewiſe an entire Circle, having the Sun for its Center. I meaſured the Semidiameter of this to be much about 22 Degrees ; the Breadth of this Arch, which was well defined, was by Eſtimate equal to the Sun's Diameter, and it was coloured with the Colours of the *Iris*, but nothing near ſo *vivid* as in the common Rainbow. The *Reds* were next the Sun, and the *Blews* in the outward Limb. Within this Circle the Sky appeared ſomewhat obſcure, eſpecially near the Arch ; and I take it, that the Cauſe of that Obſcurity was likewiſe the Cauſe that the Sun ſhone ſo faint and wateriſh. I expected two *Parhelia* at *X* and *Y* in the Interſections of this with the white Circle, having often ſeen them at that Diſtance and Poſition from the true Sun, but at this Time none ſuch appeared.

P V P, an Arch of another Circle, of which only the upper Part appeared, it was in all Reſpects, both for Breadth and Colours, like the Circle *V N X Y*, which it touched in the vertical Point *V*, but its Center was below at *N*, or near it. In the Interſections of this Arch with the white Circle on both Sides, were two very bright *Parbelia*, ſo luminous, that I do not remember to have ſeen the like, which were alſo tinged with Colours, eſpecially on the Side next the Sun, where they were very red. I meaſured their Diſtance from the true Sun, and found it 31½ Degrees. About *V* where the two Arches were coincident, it was very bright likewiſe, and the *red* on the Inſide very ſtrong, that ſome might have imagined another Sun there alſo, but the *Species* thereof was drawn out ſo in Length, that it could not properly be called a *Parbelion:* This Arch *P V P* broke off on both Sides, about five or ſix Degrees below the *Parbelia P. P.*

At *N* or the lower Part of the Circle *V N X Y*, there appeared likewiſe a ſmall Piece of an Arch, which touched it there, after the ſame Manner as *P V P* touched in *V*; it ſeemed to have its Center in *V*, and about *N* there appeared another longiſh red *Species*, ſuch as at *V*, but not altogether ſo bright.

The Height of the Sun, during the Obſervation, was from 40 to 45 Degrees, when Clouds interpoſing, no more was to be ſeen; the Weather was cooler than ordinary, with a gentle *N. W.* Wind. And it was plain, that the Vapour which cauſed this Appearance, was higher than the Clouds, for they were ſeen to drive under the Circles.

X. *June* 15, 1703, between Four and Five of the Clock in the Afternoon, I ſaw a Spot in the Sun, by placing a white Paper ſo far behind the Teleſcope of ſix Foot, as to give the Image of the Sun nine Inches Diameter; the Spot was in the lower Right-hand Quadrant of the Sun's Diſk; its Form was almoſt round, inclining to an Ellipſis; it was diſtant from the Limb of the Sun about ſix or ſeven Minutes, and its Diameter I judged to be about 10 or 12 Seconds: A little before the Sun ſet I ſaw the Spot with a 16 Foot Teleſcope, and could perceive that it was environed with a Miſtineſs. On the 16*th* I ſaw the Spot again about Two in the Afternoon, and found it advanced near to the Weſtern Limb of the Sun; the 17*th* was cloudy, and ſo was the Night, which hindered me from obſerving the Eclipſe of the Moon; the 18*th* in the Afternoon it cleared up, and a little before Five, I ſaw the Spot with the 16 Foot Glaſs through thin Clouds, and found it was now very near the Limb of the Sun, little more than half a Minute; it was much contracted in its Breadth, ſo as to be four or five Times longer than broad: On the 19*th* in the Morning, I looked for it again, but could not ſee it; ſo I concluded, it was then either gone off the Diſk of the Sun, or if it adhered to the Limb, the great Tremulation of the Atmoſphere hindered me from ſeeing it.

Spots obſerved in the Sun, in June 1703, *by Mr.* S. Gray, n. 288. p. 1502.

Aſtronomers have by theſe Spots found, that the Sun revolves on its Axis, ſo as that in 27 Days the ſame Point in the Sun's Diſk, returns to the ſame Place ſeen from the Earth; hence its Semi-revolution in $13\frac{1}{2}$ Days, and conſequently the Spot going off the Sun's Diſk the 19*th* of *June*, may be expected to return the 2*d* of *July* next to the Eaſtern Limb of the Sun's viſible Hemiſphere, if it be not diſſolved before that Time. I have in the Fig. 104. *Figure* endeavoured to expreſs the Appearance, but had not the Conveniency of meaſuring the Angle of the Spot's Way, with the Vertical, which is only gueſſed at.

June the 26*th* 1703. In the Evening I looked to ſee, whether there were generated any new Spots in the Sun, but found none; but on the 27*th*, about half an Hour after Eight in the Morning, by receiving the Sun's Image on white Paper from the ſix Foot Glaſs, I ſaw a Spot near the Vertical of the Sun towards the lower Limb; betwixt Nine and Ten I elevated the 16 Foot Tube, the Clouds now being of a convenient Thickneſs to let me ſee the Sun without Prejudice to my Eyes, and found that this Spot was of a triangular Form, and that it was accompanied with two other Fig. 98. leſſer ones, as is expreſt in the *Figure*; the Sides of the great Spot were curvilinear, this with two leſſer ones, made an Equicrural Triangle; at Four in the Afternoon the triangular Spot had a ſmall Fragment ſeparated from it, and itſelf was now become Elliptical, the Spot *b* was much augmented, Fig. 99. but the Spot *c* diminiſhed, and become longiſh, as in *Figure* 99; at half an Hour after Five the Fragment from the great Spot was itſelf divided into two, and the Spot *c* was ſo narrow as ſcarce to be ſeen; as at Fig. 100. *Fig*. 100. at Six a Clock, and 30 Minutes, there was a ſmall Fragment ſe- Fig. 101. parated from the lower End of the great Spot, as at *Fig*. 101; at Seven a Clock the Spot *b* was much encreaſed, but *c* was vaniſhed; the Obſervations made this Afternoon with the 16 Foot Glaſs, were when the Air was clear, and ſo to ſecure my Eye, the Eye-Glaſs was ſmoaked with a Wax-Candle.

The 28*th*, about Seven in the Morning, I ſaw that the great Spot was much augmented, but the leſſer ones that Yeſterday attended it, were vaniſhed, and that there were two new ones generated at about $1\frac{1}{2}$ Minutes Diſtance from the great one below, and towards the Left-hand of it the Fig. 102. great one was a Paralellogram, with a black Diagonal croſſing it *Fig*. 102; Fig. 103. at Ten a Clock there was another Diagonal croſſing the former, *Fig*. 103. and the two leſſer Spots which before were longiſh, had now taken a round Form, the Spot *c* being much larger than the other at *b*.

I am not yet furniſhed with proper Inſtruments to find the Poſition of the Sun's Spots, with reſpect to Longitude and Latitude on the Sun's Diſk, ſo I contented myſelf with obſerving the Poſition and Variation of the Spots among themſelves, which afforded me a moſt ſtrange and wonderful Variety.

On the ſame by Mr. W. Derham, *ibid.* p. 1504. Fig. 105, 106.

2.] The two Circles *Fig*. 105, 106. repreſent the Sun's Diſk, and N. the Northern Part thereof, S. the Southern, E. the Eaſtern, and W. the Weſtern Part.

The Place of the Spots, and the Manner of their Appearance every Day, is repreſented with the Day of the Month on the Sun's Disk.

But I deſire it may be obſerved, that altho' the Figures of the Spots are done pretty exactly, yet their Places on the Sun are not ſo, for being unprovided with convenient Inſtruments for the Purpoſe, I could not exactly ſet off their Delineations, nor their Diſtances from the Sun's Limb, but was forced to repreſent them only as well as I could, by taking the Species of the Sun upon Paper, through a Teleſcope, and ſo marking out their Places.

But ſince the laſt Appearance of the Spots, I have invented, and have provided myſelf with an exceeding nice Micrometer, and a Watch that beateth half Seconds, hoping to have been able to have ſeen another Revolution of them.

My Micrometer is not, as uſually, to be put into a Tube, but is to meaſure the Species of the Sun on Paper, (of any *Radius*) or to meaſure any Part of it, which I am inclined to think is more exact than the common Way. By this Means I can eaſily, and very exactly, with the Help of a fine Thread, take the Declination of a Spot, at any Time of the Day; and by my half Second's Watch, and a fine croſs Hair, (which latter Way I learnt from my Friend Mr. *Flamſtead*) I can meaſure the Diſtance of the Spot from the Sun's Eaſtern or Weſtern Limb.

This croſs fine Hair, I adviſe, from my own Experience, ſhould be ſet, not at the exact focal Diſtance from the Eye-Glaſs, (as uſually) but a little out of that Diſtance, nearer towards the Object-Glaſs, becauſe the Shadow of the Hair will be thereby much narrower, and more ſtrongly appear croſs the Species of the Sun received on the Paper, which I take this Occaſion to note, not only becauſe I believe it hath ſcarcely ever been before obſerved, but becauſe it may be of good Uſe in taking the Sun's Altitude, meaſuring his Diameter, *&c.* this being a more eaſy, and perhaps a more exact Way, than by looking through the Tube.

Being thus provided, if I could have ſeen another Revolution of the Sun's Spots, I ſhould have been able to have given a more accurate Account of their Poſition and Motion. They ſeemed ſtrong enough to have laſted another, or more Revolutions, but none have been viſible ſince the ſixth of this Month, on which Day I think I had a Glimpſe of a Spot on the Sun's Weſtern Limb, about Seven of the Clock in the Morning.

The Appearances of the Spots, being in the Figures above, ſet with every Day of the Month, I need ſay but little, only take Notice of a few Things, that the Figures do not ſo well expreſs.

The Spot in *Fig.* 105, was as repreſented, *viz.* 1ſt round and ſtrong, afterwards long, and with a *Nucleus.* The very ſame Spot (I doubt not) I ſaw again on the Sun's Eaſtern Side on *July* 5, but very faint, ſmall and long, (as in *Fig.* 106.) ſo as to be but juſt diſcernable. On *July* 6, it quite diſappeared, both through my Tubes, and on Paper, which is better.

The Spots in *Fig.* 106, had theſe remarkable Appearances and Variations. On *June* 28, viewing the Sun towards Evening, I eſpied a large, ſtrong dark Spot, with two or more glaring *Nubeculæ* behind it, ſomewhat like the Repreſentation in the Figure. Theſe the next Day were become four ſtrong dark Spots, the foremoſt with a Tail to it, conjoining the little Spot next it, as in the Figure. On *June* 30, I ſaw Spots; but it being a cloudy Morning, and I abſent from my Tubes in the Afternoon, the Repreſentation of them in the Figure is not exactly as they were. *July* 4, between two long Spots appeared ſomething like a round *Nubecula*, as in the Figure. The reſt as in the Figures.

Thus I have given the beſt Account I could of the late Solar Spots. The ſingle Spot in *June* may be ſeen to have paſſed above half over the Diſk, before a Friend of mine gave me Notice of it: And that and ſome others were, I hear, ſeen in *May*; but it was not my Fortune to ſee them ſooner; which if I had, I ſhould have been able to have made my Account better.

Spots obſerved in the Sun, *in* 1704. *by Capt.* Stannyan, n. 294. p. 1756.

On *Saturday*, *May* the 15th, 1703, As I was obſerving the Setting of the Sun, in order to examine my Clocks, there appeared two Suns, the Mock-ſun ſeemed above the Real one, which was then only five Degrees above the Horizon. Whereupon I took a good ſeven-Foot Teleſcope, with a ſmall Aperture, and ſoon diſcover'd a Solar Spot near the Sun's Center, which I deſign'd to obſerve more exactly the Day following, but it proved cloudy.

May *Sunday* no Sun-ſhine.

Monday, *May* the 17th, At Six a Clock in the Morning I took the ſame Teleſcope, armed with a clouded Eye-Glaſs, and immediately perceived that the Spot was advanced conſiderably towards the Sun's Weſtern Limb; it ſeemed of a ſtrong Conſiſtence, very compact, reſembling a Face, and was diſtant by Noon from the anterior Limb of the Sun's Diſk 61 Seconds of Time. See *Fig.* 107. Fig. 107.

Tueſday, *May* the 18th, At Noon I found the Spot diſtant from the preceding Limb 46 Seconds of Time. *Fig.* 107. Fig. 107.

Wedneſday, *May the* 19th, At Noon I obſerved the Solar Spot to be moved within 33 Seconds of Time of his Weſtern Limb. *Fig.* 107. Fig. 107.

Thurſday, *May* the 20th, At Noon the Spot was arrived within 21 Seconds of Time of the preceding Limb, and moving nearly in a ſtrait, Line; interſecting the Parallel of Declination paſſing thro' the Sun's Center. *Fig.* 107. Fig. 107.

Friday, *May* the 21ſt, We had no Sun-ſhine.

Saturday, *May* the 22d, At Seven o'Clock in the Morning I obſerved the Solar Spot was advanced very near the Limb of the Sun's Diſk. *Fig.* 107. Fig. 107.

Sunday, *May* the 23d, At Six in the Morning I ſaw the Spot, which by that Time was got to the very Edge of the Sun's Diſk, reſembling a Barley Corn, lean and ſlender, and of a duſkiſh Colour, wanting only its own ſhorteſt Diameter of the Sun's Limb. At Eight a-Clock I obſerved it again: Alſo at Ten, and at Twelve. At Two I perceived it was ſlid into the very Circumference, and hardly viſible, had I not had an Eye upon it all the Day long. At Four I examined the Sun's Body with my eighteen Foot Glaſs, which is a good one, but could not perceive the leaſt Glimpſe of it; ſo that about Three in the Afternoon it totally diſappeared. *Fig.* 107. Fig. 107.

June On *Thurſday*, *June* the 3d, About Six in the Evening I obſerved with my eighteen Foot Glaſs four Spots in the Sun's Diſk, environed with a Miſtineſs, thicker on the Right-hand than on the Left, ſituated in the upper Left-hand Quadrant, about the 12th Part of the Sun's Diameter diſtant from his neareſt Limb. From the Cloud about them proceeded both Ways five long curve Rays, of a yellower Colour than the Sun's Body. Theſe Spots I could never ſee more, though I watched them for ſeveral Days together. *Fig.* 108. Fig. 108.

On *Monday*, *June* the 7th, 1703, At Three a-Clock in the Afternoon, I diſcovered the ſame Spot (to my thinking) that I ſaw go off the Sun's Disk on *May* the 23d, re-entring the Sun's Face juſt at the Time and Place that I expected it.

At Four of the Clock, the Sun being extremely clear, I mounted my eighteen Foot Teleſcope, through which the Spot appeared diſtinct, but ſlender like a Spider, with an Elliptical ſpeckly Miſt about it, and 5 or 6 light colour'd Streaks. It ſeemed to me to be as it were divided near the Top, as in *Fig.* 109. Fig. 109.

Tueſday, *June* the 8th, At Six in this Morning the Spot was very viſible, and I ſaw it trace again its former Path, coming in exactly where I expected; it kept its Shape, but thoſe Limon coloured Streaks diſappeared, though itſelf and the Miſt about it grew bolder and broader viſibly, as it re-entred the Sun's Disk.

Wedneſday, *June* the 9th, At Five of the Clock this Evening I obſerved the Spot with the eighteen Foot Glaſs, but could not perceive it had altered its Shape, but advanced gradually over the Sun's Disk, as it had formerly done.

Thurſday, *June* the 10th, At Noon the Sun ſhining very bright, I had an Opportunity of being aſſured it was the ſame Spot; I plainly ſaw it move over its former Path, and was then diſtant from its neareſt Limb 29 Seconds of Time. At Five in the Evening I obſerved its Shape (with my eighteen Foot Tube) to be altered, appearing bigger and blacker than ever, as in *Fig.* 110. Fig. 110.

Friday, *June* the 11th, was an ill Day for Obſervations, but I had a Sight on't with the eighteen Foot Glaſs; it continued black and bold, as before.

Saturday, *June* the 12th, At Seven a-Clock in the Morning, the Sun's Body being very clear, I ſaw the Spot through the eighteen Foot Glaſs, retaining its former Shape.

Sunday, *June* the 13th, By this Day Noon the Spot was arrived at the ſame Point of the Sun's Disk, that I found it in on *Monday* at Noon, *May* the 17th, which makes me inclinable to believe it was the very ſame Spot.

Monday, *June* the 14th, according to Rules received Yeſterday from Mr. *Flamſtead*, I meaſured the Diſtance of the Spot from the next Limb of the Sun's Disk, which I found to be 45 Seconds of Time from the anterior Edge of the Sun's Body: And upon *Tueſday*, *May* the 18th, it was obſerved to be in the very ſame Place of its Path, within a ſingle Second of Time. At Four I obſerved it with my 18 Foot Glaſs, and perceived that it had alter'd its Shape, appearing as at *Fig.* 111. I received it on the Scheme, and it was diſtant from Fig. 111.
the preceding Limb 612 ſuch Parts, as the Sun's Semidiameter is 900.

Tueſday, *June* the 15th, At Noon the Solar Spot was diſtant 32 Seconds of Time, from the leading Limb of the Sun's Disk, and covered the very Place, where the ſame Spot had been obſerved on *Wedneſday* the 19th of *May*.

Wedneſday, *June* the 16th, No Sun-ſhine.

Thurſday, *June* the 17th, No Sun-ſhine.

Friday, *June* the 18th, At Noon I obſerved the Solar Spot waxing very ſlender, but notwithſtanding that, it was black and bold to Appearance, the Miſtineſs about it on the Right-hand perceiveable, and that on the Left grown ſlender, in Proportion with the Spot itſelf, and found it diſtant 5 Seconds of Time.

Saturday, *June* the 19th, At Five this Morning, it being clear Weather, I ſaw the Spot diſtinctly with my ſeven Foot Tube : At Nine a-Clock I mounted my eighteen Foot Glaſs, obſerving once in half an Hour all the Morning : At Twelve I perceived, that all the Cloud or miſty Matter, that uſed to ſurround the Spot, was inviſible, and the Spot itſelf reduced to little or no Breadth, in Compariſon to what it had been towards the Sun's Center, and ſo cloſe to the Limb of the Disk, that I could only perceive a ſmall Streak of the Sun's Light between it, and the Limb of the Sun's Body : At Two a-Clock I could juſt perceive it, but grown extremely ſlender.

The firſt Revolution, I ſaw the Spot half in the Circumference of the Sun's Limb at Two a-Clock on *Sunday*, *May* the 23d : And the ſecond Revolution, I juſt perceived it with the eighteen Foot Glaſs, at half an Hour after Two a-Clock on *Saturday* the 19th Day of *June*.

On *Sunday*, *June* the 27th, About Six a-Clock in the Evening, I obſerved ſeveral Spots in the Sun's Disk, but had not the Conveniency to uſe my longeſt Teleſcope, becauſe of ſome Trees that were in my Way to Weſtward, ſo that I made no Obſervation till *Tueſday* following.

Fig. 112.

Tueſday, *June* the 29th, About Seven in the Morning I counted 16 remarkable Spots in the Sun's Body, and near his Center they appeared as in *Fig.* 112, through the eighteen Foot Glaſs ; then I took my ſeven Foot Teleſcope and Frame, and obſerved, that the foremoſt Center of ſix, that looked on the Paper as one Spot, was diſtant from the Sun's anterior Limb 81 Seconds of Time, and the laſt Cluſter 87.

This Day the foremoſt Spot was diſtant from the following Limb, according to the Path of the Spot, juſt 55 Seconds of Time. The Sun's Diameter was always 136 Seconds in the Tranſit, and the Spot was 126 : So that the Spots Path was 10 Seconds ſhorter than the Sun's Diameter.

Fig. 113.

Wedneſday, *June* the 30th, At Eight a-Clock this Morning, obſerving the Solar Spots with my eighteen Foot Teleſcope, I perceived very plain, that they had wonderfully increaſed in Number, and ſtrangely changed their Places. The Cluſter of ſeven Spots ſeemed to me to move gradually, as the ſingle Solar Spot did in *May*, but the Cluſter 4 went too faſt forward, the 12 Spots without a Miſt about them ſtraggled all Manner of Ways, and the 9 Spots and the 5 black little ones went backward and unbent itſelf at the ſame Time as it were into a ſtreight Line. I am apt to believe it went backward, as that the other went too faſt, or faſter than ordinary forward ; for in 24 Hours, the foremoſt Cluſter advanced 21 Seconds of Time, which is more by 6 Seconds than ever the ſingle Spot moved in that Time, even when neareſt.

neareſt the Sun's Center; and the Diſtance in Time between the firſt and the laſt Cluſter this Day was greater by three Seconds than the Day before.

The foremoſt Cluſter of 4 Spots was diſtant from the advancing Limb of the Sun 60 Seconds of Time.

At half an Hour paſt Four the advancing Cluſter paſſed the Interſection in 55 Seconds of Time, after the Sun's foremoſt Limb had paſſed conformable to the Spots Path; and the laſt Spot paſſed in 63 Seconds of Time, the laſt Limb paſſing the Interſection, according to the Path of the Spot, in 126 Seconds of Time, the Sun's largeſt Diameter paſſing in 136 Seconds; the Fig. 113. Spots by this Time appeared ſtrangely black, and of very odd Shapes, as in the upper Part of the Circle.

Thurſday, *July* the 1ſt, At Eight a-Clock in the Morning, I obſerved the *July.* Solar Spots with my eighteen Foot Teleſcope, the Weather being good, and ſaw that they had ranged themſelves in reſpect of one another, as is repreſented in the upper Part of the Scheme: The leading and largeſt Spot being Fig. 114. diſtant from the anterior Limb 44 Seconds of Time, the laſt Cluſter lying a little awry, paſſed in 53 Seconds: After the anterior Limb had ſo done, the following Limb alſo paſſed the Interſection, according to the Path of the Spot, in 125 Seconds of Time.

Friday and *Saturday*, No Sun-ſhine.

Sunday, *July* the 4th, This Morning at Eight a-Clock the leading Spot was diſtant from the advancing Limb 10 Seconds of Time, the Spots and Cluſters retaining nearly the ſame Shape, but beginning to contract themſelves, the foremoſt methought looked ſtrong enough to make another Revolution, and paſſed in 127 Seconds.

Monday, *July* the 5th, At Seven a-Clock I found the Spots had quite altered their Shape, appearing dull and ſlender, as in the lower Part of the Scheme, and diſtant about 4 Seconds, being all included in a Cloud.

Tueſday, *July* the 6th, At Ten a-Clock the Sun's Diſk, viewed with my eighteen Foot Teleſcope, was found clear of all Spots.

On the 17th Day of *July*, about Four a-Clock in the Afternoon I obſerved ſome Spots in the Sun's Body, reſembling thoſe I ſaw on *Thurſday* the 3d of *June*, only with this Difference, that theſe appeared to me as if they had been heated red hot; they ſeemed to be in the ſame Part of the Sun's Diſk. I obſerved them above an Hour together that Day, but could never afterwards ſet Eye on them, nor diſcover whether they were coming in, or going off his viſible Diſk. I continued to obſerve the Sun as often as was poſſible, with my eighteen Foot Glaſs, till the End of the Month, but without farther Succeſs.

4.] I have endeavoured to render this Account of the Spots of the Sun *Spots in the Sun from* 1703 *to* 1708, *by Mr.* W. Derham, n. 330. p. 270. more complete than my former; few of thoſe Appearances having eſcaped my Sight; and being alſo better provided with competently good Inſtruments to take their Places on the Sun, *viz.* a *Micrometer* (after Mr. *Gaſcoign*'s Manner) to take their Diſtance from the Sun's Northern or Southern Limb, which is parallel with the Pole of the Earth; and a *Half-Second's Movement*, to meaſure their Diſtance from the Sun's Eaſtern or Weſtern Limb.

A Table of all the Spots *and* Faculæ *on the* Sun, *viſible at* Upminſter *ſince* July 1703.

1703.		*Jun.* 23. *none*			8		30	*Feb.*	14	*Nov.*	1
		Some	24	*	10				15		4
Octob.	9	*Vaniſhed*	25	*	22	*April*	2		16		8
	10			*	23	*Vaniſhed*	3		18		10
	11	*July*	18						24	N. B. *This* Nov. 15. *another Spot aroſe on the Eaſtern Side of the Disk whilſt this on the Weſtern.*	15
			20	*June*	22	*June*	7				16
Nov.	19		21		23		8	*March*	6		17
	22	*	23		24				9		18
					26	*July*	24		11		19
		Sept. *	10		27		25		12		20
		nothing	14		28						22
1704.			18		30	*Sept.*	4		14		
		*	21	*July* *	1		5		18		
Jan.	16			*	3		6		21		
	17	*Nov.*	17				7				
	18		18		24		8	*June* *	29		
	19		21				10	*Extinct*	30		
	21			*Sept.*	30	*Faint*	11				
	22	*Dec.* *	2	*Octob.*	2	*Extinct*	12	*July*	1		
	23				3			*Languid*	2		
					5	*Oct.* *	29	*Scarce viſible*	4		
					6						
Jan.	30	1705.			7	*Nov.*	5	*More viſible*	5		
						Faint	6				
Feb.	23	*Jan.*	1		25	*	8	*Extinct*	6		
	25		2		26			*Appears*	8		
			3		30		28	*	10		
Mar.	7		5		31		29				
	8			*Nov.*	2		30				
	9	*	25		4	*Dec.*	1	*Aug.* *	31		
	10						2				
	11	*Feb.* *	19	*	21		3	*Sept.* *	12		
	13						4		16		
		March	14				5	*Spot &c* *	17		
			16	1706.					19		
April	11					*	22		21		
	12	*April*	1	*Feb.*	7	*	31		27		
	13							*No Spot nor* *	28		
		May	5	*Mar.*	7						
May	1		6								
*	11		7		27	1707.		*Octob.*	31		

In this Table the *Faculæ* are noted with an Aſteriſk; and the Duration of every Appearance of the ſame Spots or *Faculæ*, or the Time they diſappeared, with a Line.

Out of many Things that I took Notice of in viewing the Spots and *Faculæ*, I ſhall ſelect only ſome few Obſervations, which are the moſt remarkable.

And firſt, as to the *Figure* of the Spots. They are well known to change frequently; and therefore I think it of little Uſe to give their Figures every Time I obſerved them. But it is ſomewhat remarkable, that the Spots generally appear longiſh near the extreme Parts of the Disk. If they are never ſo round near the Middle of the Disk, they become longer and longer towards the Extremes, till (at going off) they ſeem to be nearly a ſtrait Line, nearly parallel to the Sun's Limb. Which is a manifeſt Argument, that the Sun is a Globe, and that theſe Spots are on, or very near its Surface.

Another Thing remarkable is, the *Mutability* of the *Shape* of the Spots. I have more than once manifeſtly perceived them to change in the very Time I have been looking upon them. Thus *Nov.* 19, 1703, I ſaw three or more Spots not far off the Middle of the Disk; and whilſt I was looking upon them, they ſeemed to vary, both as to their Shape and Strength; ſometimes ſeeming longer, ſometimes ſhorter; ſometimes ſpiſs, ſometimes languid. And this they ſeemed to do, not only through my ſixteen Feet Tube, (which I thought at firſt was from the different Diſpoſition of my Eye) but alſo when I received the Sun's Image through a ſix Feet Teleſcope, on a white Paper, in a darkened Room. Theſe mutable Spots the Weather hindred me from ſeeing again till *November* the 22d following; and then they were become only like a thin Smoak, or *Nebula*.

So again *April* 11, 1704, there were divers Spots with *Umbræ* about them. Theſe *Umbræ*, or *Nebulæ*, I could plainly perceive, whilſt I was looking on them, to be ſometimes very faint and thin, and ſometimes much darker and thicker. Theſe *Maculæ* and *Umbræ* I obſerved ſuddenly brake out in the Sun: For on *April* 9, the Disk was free. But this *April* 11. laſt mentioned, I perceived them advanced near a quarter Part on the Disk: And conſequently they brake out in the Sun within 48 Hours before. On *April* 13, the Spots were become *Umbræ* in the Morning; and at Four of the Clock in the Afternoon, there were no Remains of either *Maculæ* or *Umbræ*.

From this *ſhort Continuance* of theſe Spots on the Sun, it is more than probable, they were in a perpetual Flux and Change; and that thoſe Mutations, which I perceived in them, whilſt I was looking on them, were real, not imaginary.

Alſo it may be farther remarked, (which I have frequently obſerved, and which as I remember *Scheiner* obſerved long ago) That thoſe *Spots* and *Umbræ*, which *ſuddenly* ariſe, do as *ſuddenly* decay, and are ſoon *extinct.* And ſuch Spots, I have farther obſerved, do ſeldom turn to *Faculæ*, as they commonly do when longer on the Sun.

Again, *May* 5, 1705, I could perceive two Spurs or Branches (running from a Spot) to change, and be ſometimes darker, ſometimes thinner.

So *March* 30, 1706, I obſerved ſuch another Variation. This Day, or but a little before, *Spots* with *Faculæ* aroſe in the Sun, which remained not above three Days on him. One of theſe Spots I could manifeſtly perceive to be ſometimes quite extinct, and then again immediately to appear: And the *Faculæ* alſo, in half an Hour's Time, had plainly altered their Shapes.

October 29, the ſame Year, I could plainly perceive the *Maculæ* and *Faculæ* both to change: And whilſt I was carefully viewing them, I ſaw a Spot ariſe in one of the brighteſt *Faculæ*, and again nearly diſappear; and then again appear ſtrong and ſpiſs. I ſhould have been glad to have ſeen how they appeared next Day; but the Weather was ſtormy, cloudy, and wet for ſeveral Days after.

Another Thing I have obſerved (and not having the Book by me, I forget whether *Scheiner* obſerved the ſame or not) is, That the *Maculæ* do generally, if not always, become *Nebulæ* or *Umbræ*, before they quite vaniſh; and after that, very frequently turn to *Faculæ*, or bright golden Spots, more illuſtrious and fulgid than the other Parts of that glorious Globe. If the Spots are of a ſhort Duration, *Faculæ* ſeldom enſue: Or if they do, they are commonly the Remains of ſome Spots that had been on the Sun, and vaniſhed perhaps on the Side oppoſite to us. But Spots that *long continue*, if they vaniſh, before that Part of the Sun revolveth out of our Sight, do very often become *Faculæ*: Of which the Table affordeth ſeveral Inſtances, particularly *July* 3, 1705.

From theſe preceding Particulars, and their Congruity to what we perceive in our own Globe, I cannot forbear to gather, *That the Spots on the Sun are cauſed by the Eruption of ſome new Vulcano therein*; which at firſt, pouring out a prodigious Quantity of Smoak, and other opacous Matter, cauſeth the Spots: And as that fuliginous Matter decayeth and ſpendeth itſelf, and the Vulcano at laſt becomes more torrid and flaming, ſo the *Spots* decay and grow to *Umbræ*, and at laſt to *Faculæ*; which *Faculæ* I take to be no other than more flaming brighter Parts than any other Parts of the Sun. Theſe *Faculæ* I have obſerved *never* continue *long* on the Sun: And the Reaſon I conceive is, becauſe the *Vulcano*, after its Smoak is over, doth not long emit its Flames, by reaſon the fiery *Pabulum* is then near ſpent, when once it begins to flame: After which the torrid *Vulcano* ſoon returneth to the natural Temperature of the Sun, ſo nearly at leaſt, as to eſcape our Sight, at ſo vaſt a Diſtance as the Sun is from us.

Another Thing, that may be accounted for, and indeed doth in ſome Meaſure confirm alſo what I have ſaid, is the *Nuclei*, or darker Part of

Fig 94

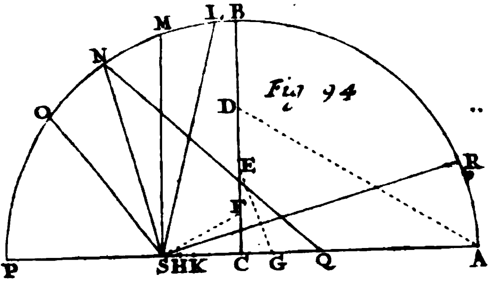
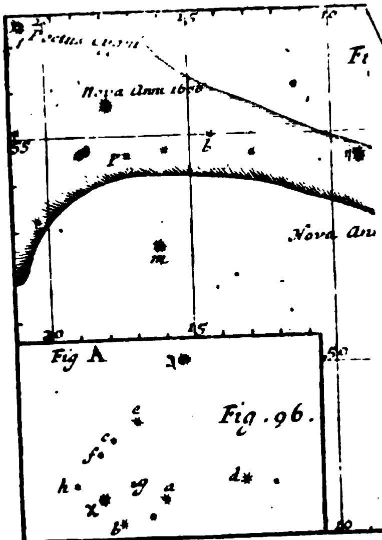
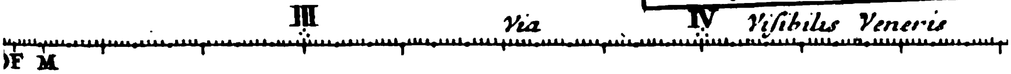


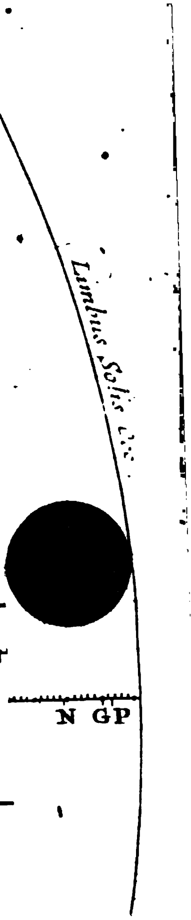
Figura Veneris Solis Discum intrantis.

Fig A

Fig . 96 .







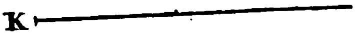


Fig . 104 .

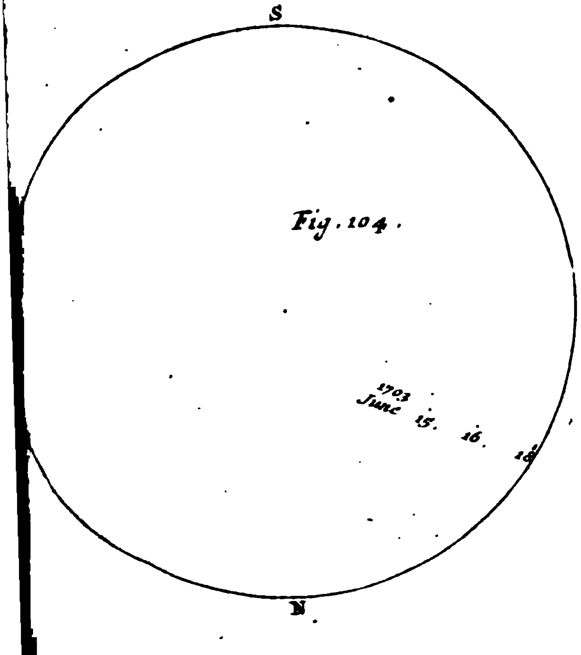
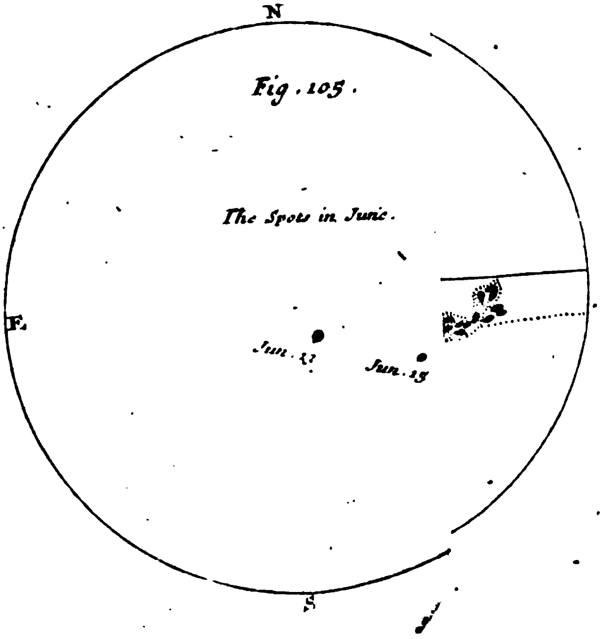


Fig . 105 .

The Spots in June .



of the Spots; generally in moſt Spots, and towards the Middle of them. Now it is very uſual in culinary Fires in this our Globe, when they emit Smoak, that the Middle is the darkeſt Part. If, for Inſtance, we were from aloft in the Air, to ſee a thick Smoak come tumbling out of a *Chimney*, or the Mouth of a *Vulcano* juſt kindled, we ſhould find the middle Part, juſt over the Mouth of the *Chimney*, or *Vulcano*, to be the more ſpiſs and dark, and towards the Extremes clearer and thinner. And ſo I take it to be in the Eruptions of the Sun; that the *Nucleus* is juſt over the Mouth of the ignivomous Cavern, and that the miſty Parts of the Spot are the thinner Parts of the Smoak, ſwimming about in that Fluid, or *Atmoſphere*, which I ſuppoſe doth ſurround the Sun, as well as our Globe, and the Moon manifeſtly; yea, and in all Probability, every Planet of this our Solar Syſtem.

From what hath been ſaid, we may give a Reaſon, why there are ſometimes Spots *frequently* on the Sun, and ſometimes *none* in many Years. One Thing I believe there is in this, That there may be Spots, but not always ſeen. But there are doubtleſs great Intervals ſometimes, when the Sun is free; as between the Years 1660, and 1671, 1676, and 1684. In which Time Spots could hardly eſcape the Sight of ſo many curious Obſervers of the Sun, as were then perpetually viewing him with their Teleſcopes in *England*, *France*, *Germany*, *Italy*, and all the World over; whatever might be before, from *Scheiner*'s Time. The Reaſon of this long Diſappearance of the Spots, I take to be from the Want of extraordinary Eruptions in that fiery Globe. The ſulphureous, or other Matter, or *Pabulum* of thoſe Eruptions, is ſpent or diſſipated, and that Globe continues in its natural ordinary burning State, till there happens to be a freſh Collection of ſmoaking, diſploſive, and extraordinary Matter, that cauſeth a new Eruption: Which Eruptions generally happen between what we may call the Sun's *Tropicks*, or in his Torrid Zone: For I never obſerved any Spots to be near the Sun's *Poles*. And if I miſremember not, the Spots in *Scheiner*'s Cuts are all about the middle *Zone* of the Disk. The greateſt Evagation I ever obſerved of them was *March* 8, 170$\frac{3}{4}$. On which Day, beſides the dark Spots in the uſual Zone, I perceived ſome faint Spots, ſcarce viſible, much nearer the Southern Pole, than I ever had ſeen them. But this was, no doubt, in ſome Meaſure owing to the Poſition of the Earth in reſpect of the Sun, as well as to the Southerly Place of the Spots on him: For, about the Equinoxes, the Spots ſeem to march pretty far towards the Poles of the Sun, as may be ſeen by the *Schemes*. Fig. 115, 116.

Having thus obſerved, what *Part* of the Sun the Spots commonly poſſeſs, I ſhall next take Notice of their *Stages* and *Path* over the Sun. That the Sun moveth round his own *Axis*, is manifeſt, beyond Doubt, from the Motion of the Spots. And that the Spots ſeem to traverſe the Sun, ſometimes in ſtrait Lines, ſometimes in Curve Lines, curved this Way, and that Way, is as manifeſt alſo, and well known, and is ſet forth in the Figures: Which Figures ſhew the Stages of the Spots, every Day that I obſerved them, and the Lines they deſcribe in ſeveral Months of the Year. The daily Stages in both Figures are exact; or if they ſeem otherwiſe, it is by reaſon the Obſervations were made at different Times of the Day; as One in the Morning, the other ſome following Day in the Evening, or Afternoon. But the Declinations of the Spots, or their Diſtances from the Sun's Northern or Southern Limb, are leſs exact in the 116th Figure than the 115th, in which latter they are very near the Truth.

And the Cauſes of the Defects in the 116th Figure I ſhall mention, to prevent the ſame Errors in others I myſelf ran into.

1. The Diminution of the Sun's vertical Diameter by the Refractions was the principal Cauſe of my Errors. This, although I was ſufficiently aware of, yet I did not think had been ſo conſiderable, for Want of experimenting, or well conſidering the Matter: For I have ſometimes found the perpendicular or vertical Diameter of the Sun diminiſhed, from $32', 21''$ on the Meridian, to $26', 3''$ at the Horizon, in one and the ſame Day.

2. For the ſame Reaſon I was not aware of the Time being ſo long, before the Sun goes round, as I found it.

3. Another Error was meaſuring the Sun's Image on the Scene of white Paper, with the Shade of the Micrometer; and not by looking through the Tube, and ſo claſping the Limb of the Diſk with the parallel Edges of the Micrometer. The former, although practiſed by ſome eminent Aſtronomers, is a far more eaſy and indulgent, than accurate Way.

—Spots—from 1707, *to* 1711, *by the* ſame, *ibid.* p. 278.

5.] I have ſince ſeen other Spots on the Sun, whoſe Times are expreſſed in the *following Table.*

Fig. 117.

Fig. 117.

From my Obſervation of theſe Spots, I am farther confirmed in the Opinion I expreſſed in the foregoing Paper: Particularly in viewing the Spots of *Auguſt* 1, 1708, (repreſented *Fig.* 117.) where ſome were large and dark, others leſs and thinner, and all encompaſſed with *Nebulæ*. In viewing theſe, I obſerved great *Alterations* at the very Time I was looking on them. Sometimes the *Nuclei* were very dark and black, ſometimes leſs ſo; and the ſame Thing I obſerved alſo in the *Nebulæ* encompaſſing them. One of the leſſer Spots *b* in *Fig.* 117, which the Day before was ſufficiently viſible and ſtrong, was, this Day now thick and ſtrong, and Anon languid and leſs viſible. And from the two Spots *a* and *d* I could plainly ſee a Smoak iſſuing out to *c* and *f*, ſometimes viſible for 5 or 6 Minutes, and then diſappearing for a Quarter of an Hour, or more; and then again ſmoaking out, and again diſappearing, as before. All which Particulars I ſaw over and over again repeated, for a good While together, till I was weary of the Obſervation.

1707.	1709.
Decemb. 4	*Jan.* 15
10	21
	22
* 29	
* 30	*Auguſt* 13
	* 17
1708.	*Octob.* 8
July 31	
Auguſt 1	*Novemb.* 1
5	2
6	4
	5
22	6
23	
24	1710.
28	
Septemb. 1	*Jan.* 22
Novemb. 5	*April* * 6
Dec. 14	*Octob.* 14
26	* 18

Fig. 117.

Theſe Spots I was hindred from viewing until *Auguſt* 5, following: And then I found the Spot *b* quite extinct, (as I expected) as alſo ſome of the other Spots; together with the *Nebulæ* grown leſs. But the great Spot *a* continued dark and ſtrong, only ſometimes fainter, and then again ſtronger; and ſometimes like a half, or horned Moon; ſometimes roundiſh, or rather of an oval Figure; of which latter Figure they commonly are, when they are near the Sun's Limb, which this Spot was not far off at this Time.

Theſe Particulars are Confirmations of what I ſaid, *That the Solar Spots are no other than a Smoak riſing out of the Body of the Sun.* Of which Opinion I have been, almoſt ever ſince I firſt obſerved them, and find that I am not ſingular in this Opinion, as I ſhall ſhew from Part of a Letter (which with ſome others is lately fallen into my Hands) from Mr. *Crabtrie* to Mr. *Gaſcoigne*, the Inventor of the Micrometer.

Mr. Crabtrie's *Opinion of theſe* Spots, *in a* Letter *to Mr.* Gaſcoigne, *of* Auguſt 7, 1640.

'I writ to Mr. *Townley* my Opinion in Brief of the Sun's Spots, '(which you conceive to be Stars) and it ſeems he, or Mr. *Kay*, writ 'to the ſame Purpoſe to you, deſiring your Opinion: Which you freely deliver: Yet give me Leave to ſpeak my Mind likewiſe freely con'cerning theſe Appearances. I do not value the Authority of *Galilæus*, 'or *Kepler*, further than either demonſtrative, or the moſt probable 'Reaſons confirm their Opinions. I acknowledge you ſay more for 'the Stellifying of theſe Solar Obſcurities, than I have heard before; 'yet I conceive not ſufficient, either demonſtratively or probably to 'countermand thoſe, which *Galilæus*, *Kepler*, and others have produced 'to the contrary; nor yet ſuch as can be cleared from ſuch Objections, 'as Reaſon, Demonſtration, and Obſervation may lay againſt them. 'My Occaſions will not admit a full Diſquiſition hereof at this Time; 'yet ſomething I would ſay for the preſent, the better to furniſh you 'where to object, when I ſee you.

‘ I have often obſerved theſe Spots; yet from all my Obſervations ‘ cannot find one Argument to prove them other than *fading Bodies.* ‘ But that they are no Stars, but unconſtant (in regard of their Gene- ‘ ration) and irregular Excreſcences ariſing out of, or proceeding from ‘ the Sun's Body, many Things ſeem to me to make it more than ‘ probable.

‘ For firſt, for their *Form*; they are ſeldom round, but of irregu- ‘ lar Shapes, and, as I have often ſeen, one Side, or End of the Spot ‘ more thin than the reſt, like to a certain miſty Darkneſs, and by De- ‘ grees thicker, groſſer, and darker, nearer to the main Body of the ‘ Spot; juſt as the Smoak of ſome pitchy Fire, which is in one Part ‘ very groſs, and in another more rare and thin, turning at laſt into ‘ mere Air: Or like a Cloud, Fog, or Miſt, more thick, dark, and ‘ groſs in the Midſt; and more thin, fluid, penetrable, and tranſparent ‘ towards the Sides; which I ſuppoſe is not compatible with any of the ‘ Stars.

‘ Secondly, for their *Colour*: The Lightneſs thereof differenceth them ‘ from Stars, or Planets; they being never of ſuch abſolute Darkneſs, ‘ as I obſerved *Venus* the 24th of *November* laſt: Though I have ſeen ‘ Spots ſometimes little leſs than ſhe, yet always of a far paler and ‘ whiter Colour, looking (at leaſt in ſome Parts) like ſome thin diſſipa- ‘ ted Subſtance.

‘ Thirdly, for the *Manner* of their *Appearance*. I have ſeen many ‘ Spots, which in the Middle of the Sun appear of a round Body, but ‘ coming towards the Side of the Sun, appear long. Which is a de- ‘ monſtrative Argument, that they are not Globes, as all the Planets ‘ and Stars are: For Globes always appear of one Form (round) in ‘ every Poſition; but Exhalations, or ſuch like fluid Subſtances, ex- ‘ tended to a broad flat Form, like our Clouds, which being over our ‘ Heads, and ſo in their full Breadth, appear large and broad; but ‘ driven with the Wind, till they turn one Edge upon us, ſeem of a ‘ long Shape. So theſe Solar Clouds, being turned about the Sun, may ‘ in the Middle ſhew their full Breadth to us, and about both Edges ‘ of the Sun, turn their Edges to us: Which anſwereth to the Appear- ‘ ance.

‘ Fourthly, for their *Continuance*. Some of theſe Spots, ariſing at the ‘ Eaſt-ſide of the Sun, vaniſh before they come to the Midſt of the Sun. ‘ Others appear firſt in the Middle of the Sun, and vaniſh before they ‘ come to the Weſtern Limb; and for the moſt Part they vaniſh, be- ‘ fore they have made a full Revolution about the Sun. Which argues ‘ them to be but thin, vaniſhing, fading Subſtances, not like the per- ‘ manent Bodies of the Stars.

‘ But to take off theſe Reaſons, you anſwer, That you conceive ‘ theſe Spots to be Stars moving regularly in their own Orbs, which

‘ are many, though none of greater Extent than about $\frac{1}{10}$ of the ☉ Semidiameter
‘ from its Circumference; and that the ſwifter Movers in
‘ the lower Orbs, overtaking the ſlower in the higher Orbs, cauſe an
‘ Appearance. You ſeem therefore to think, that they being ſo thin
‘ Bodies, the Sun's Rays paſs through them, and ſo one cannot be ſeen
‘ alone, till more being together, one heaped behind another, they ſtop
‘ the Light of the Sun's Rays, and ſo cauſe an Appearance. This I
‘ conceive is your Meaning: Or elſe (as you ſeem to inſinuate afterwards)
‘ that the higher reflects the Sun's Rays ſtrongly enough upon
‘ the lower, (when they come within the Angle of Reflection) to make
‘ the interjacent Planet indiſcernible.

‘ But to theſe I anſwer, that

1. ‘ If it be by their coming within the Angle of Reflection, that
‘ the Light of the Sun reflected from the outer Planet upon the inner,
‘ doth make it (as you ſpeak) indiſcernible, then that Light ſo reflected,
‘ is reflected either upon all Places, as the Moon and Planets
‘ Light; or but upon one, as is the Reflection of a plain Looking-Glaſs.
‘ If the *Firſt*, there would never be many ſeen, (ſeldom above
‘ one or two) becauſe the outermoſt would continually make the inner
‘ undiſcernible. But *Gaſſendus* affirms, there are ſeen ſometimes 40 at
‘ once in the Sun's Body. If the ſecond, there would always be many
‘ ſeen, becauſe the reflected Light would but occupy a little Room,
‘ and that but for a ſmall Time, till the ſwifter were paſt the Place of
‘ Reflection: Whereas many Days there are none at all ſeen in the
‘ Sun's Hemiſphere: And in both theſe Caſes, the outermoſt Planet
‘ of all would always in the Space of 27 Days, be ſeen in the ſame
‘ Place, being never obſcured, none of the Inferior being able to reflect
‘ Light upon it. Add hereunto, if any Kind of Reflection ſhould
‘ make them to appear bright like the Sun, and ſo not diſtinguiſhable
‘ from the Light of the Sun, what ſhould [a] hinder, but we ſhould ſee
‘ them alſo bright Bodies by the Side of the Sun, when they are paſſing
‘ either by the Weſt or Eaſt-ſide of the Sun's Body? The Light
‘ being then reflected upon them by the inferior Planets, as well as at
‘ other Times, and that alſo upon much of that Side of them which we
‘ ſhould behold.

---

[a] N. B. *Mr.* Gaſcoigne *having, againſt theſe Words, inſerted a rough-drawn Figure in the Margin of Mr.* Crabtrie's *Letter, I have alſo repreſented it in* Fig. 118. *imagining it may ſomewhat explain Mr.* Gaſcoigne's *Hypotheſis, and what Mr.* Crabtrie *ſaith againſt it.* Fig. 118.

‘ But if you wave this Conceit, as inſufficient, and fly to your former, That the ſwifter Movers in the lower Orbs, overtaking the ſlower in the higher Orbs, cauſe an Appearance. To this I anſwer: 1. The Thing you ſuppoſe ſeems to me neither neceſſary nor probable, nor do I conceive, why they ſhould not be ſeen, being themſelves alone, as well as conjoined, ſeeing all other Stars and Planets are ſo. 2. If it be, becauſe they are of a thin, tranſparent Subſtance, till many, being one behind another, make them to ſeem groſſer; then they are not of the Nature of other Planets, as is proved in ☿ and ♀, who of themſelves appear dark Bodies, when they come between us and the Sun; nay, they muſt be more thin than our Clouds, which will eaſily be ſeen between us and the Sun, and hide it from us. 3. If it be, becauſe they are ſo little, that the Imperfection of our Glaſſes cannot diſcover one alone, there muſt be, without doubt, many Millions of them; which how they can be included within the Compaſs of $\frac{1}{10}$ of the ⊙ Semidiameter, we ſhall conſider anon. I have ſeen one of an ordinary Darkneſs, (yea darker than many greater) yet not above 5″ Diameter. If this conſiſt of two, or many, of themſelves inviſible, how many were in thoſe which *Gaſſendus* ſaw of 1′ ½ Diameter? 4. The Figure of theſe great ones (being neceſſarily compoſed of Stars of ſuch different Orbs and Motions) would quickly vary, by reaſon of the Diverſity of their Motions; like as we ſee in a Flock of ſmall Birds. But 5thly, You ſay the furtheſt of theſe Orbs is not above $\frac{1}{10}$ of the Sun's Semidiameter from its Circumference. But there would not, in that ſmall Space, be Room enough for ſo many Orbs of Planets, as have been ſeen at once. Which I prove thus: 1. *Gaſſendus* affirms, there are ſometimes ſome of about the $\frac{1}{10}$ Part of the ⊙ Semidiameter; which is the whole Space allowed by you for them all. And myſelf have ſeen of the $\frac{1}{15}$ of the ⊙ Semidiameter: And yet you muſt confeſs, theſe great ones could only be Conjunctions of ſome, not all. 2. There are many Times ſeen in the Sun's Superficies, a great Number of Spots, whoſe Diameters added together, would do more than twice fill the Space you ſpeak of. I myſelf have ſeen it, and ſo I believe have you. *Gaſſendus* affirms, there are ſometimes 40 ſeen at once: If this was by Conjunction of Planets, in every Appearance, there were at leaſt 80 Bodies at once on this Side the ⊙; it may be as many on the other Side, beſides thoſe unſeen, (by your Reflection or otherwiſe) which doubtleſs muſt be far more than ſeen. For it is a moſt rare, and I think unheard of Thing, to ſee but three (which is leſs than the Half) of our Planets, conjoined in viſible ☌ at once: So that without Queſtion, if they be Planets, they are many Hundreds; which muſt have ſo many ſeveral Orbs, and which certainly cannot be done in ſo narrow a Compaſs, as the $\frac{1}{10}$ of the ⊙ Semidiameter. And that they cannot have any larger (I ſuppoſe not ſo ‘large an) Extent from the ☉ Superficies, may be proved by their Motion through the viſible Hemiſphere of the Sun's ſpherical Body, by comparing the Swiftneſs of their Motion towards the Middle and Sides together. 6. If one of theſe (imagined) Planets be ſwifter than another, as they muſt needs be, then the ☌ of 2 or 3 ſwifter ones would make a Spot of ſpeedier Motion than the ☌ of 2 ſlower ones: But the Motion of all about the ☉ Center, is always equal; yea, and the Spots retain the ſame Poſition one to another, (conſidering the Sun's Sphericity, and the Angle of their Appearance to us) juſt like the fixed Stars. So affirms *Gaſſendus*, They all move with the ſame uniform Motion, ſo that when there are ſeveral of them, no one overtakes another, but they all preſerve the ſame Diſtances in the Sun's Diſk, as the fixt Stars do in the Firmament.

‘As for that other *annual Motion* of the Spots, you ſpeak of, from Weſt to Eaſt, upon their Axis inclined above 8 Degrees to the Ecliptick; I ſuppoſe it is not any real Motion of the Orbs of thoſe ſolar Planets or Spots, but only a viſible Motion ſo appearing, cauſed (in *Kepler*'s Syſtem) by the Sun's rolling upon its own Center in the Midſt of all the Orbs, and not exactly in the Way of the *Temporary* Ecliptick, but in the *Via regia* (as *Kepler* calls it) inclined certain Degrees to the *Temporary*; thereby turning about with him, the ſame Way, his adventitious, or excrementitious Parts, the Spots, by his *magnetical* or *ſympathetical Rays.* And hence may be demonſtrated the Appearance of that annual Motion in the Sun's Spots you ſpeak of. See *Galilæus*, *Syſt. Coſm. p.* 339, *& ſeq.* So alſo in *Ptolemy*'s and *Tycho*'s Syſtem, the ſame Appearance may be demonſtrated, ſuppoſing the ⊖ fixed in the Middle of the Univerſe, and the ☉ rolling round upon the ſame Poles of that *Via regia* (or way of the Spots) and keeping his Axis in Paralleliſm continually towards one and the ſame Part of the Univerſe. This may be certainly demonſtrated, although *Galilæus* there affirms the contrary. Other *Hypotheſes* of that Motion may be feigned, as by the annual Converſion of the Poles of the *Via regia* about the Poles of the Ecliptick in the Sun's Body: But none I conceive ſo compendious, as the one of the former. For my Part, I incline to the firſt.

‘Thus you have, what for the preſent, I conceive of theſe *Maculæ Solares*. *Fromundus* mentions one *Jo. Tarde Gallus*, who thinks them to be ſecondary Planets; who hath written a Book of that Subject, and calls them *Aſtra Borbonia:* But I could never yet ſee it. What you, or he, or others may alledge for that Opinion, I know not. In the mean Time I cannot acknowledge them Stars, unleſs I ſee at leaſt ſome Poſſibility how they may be ſo, or ſome Probability why they ſhould not rather be Spots. Which when you, or they do produce from better grounded Reaſons, Optical Experiments, or Demonſtrations, I ſhall willingly recant my Opinion.

It

Of the Diameter *of* Venus.

‘ It is true which you ſay, That I found *Venus*'s Diameter much leſs than any Theory extant made it. *Kepler* came neareſt, yet makes her Diameter five Times too much. *Tycho*, *Lansberge*, and the Ancients, about 10 Times greater than it was. So alſo they differ in the Time of the ☌ as far from the Truth. By *Lansberge* the ☌ ſhould have been 16^{h} 3′ before we obſerved it: By *Tycho* and *Longemontane* 1^{d} 8^{h} 25′ before. By *Kepler* (who is ſtill neareſt the Truth) 9^{h} 40′ before. So that had not our own Obſervations, and Study, taught us a better Theory than any of theſe, we had never attended at that Time for that *rare Spectacle*. You ſhall have the Obſervation of it, when we ſee you. The Clouds deprived me of Part of the Obſervation, but my Friend Mr. *Jeremiah Horrox*, being near *Preſton*, obſerved it clearly from the Time of its coming into the Sun, till the Sun's ſetting; and both our Obſervations agreed, both in the Time and Diameter, moſt preciſely.

‘ *Langsberge* in Eclipſes, eſpecially of the ☽, comes often nearer the Truth than *Kepler*, yet it is by packing together Errors; his Diameter of the ⊙ and ☽ being falſe, and his Variation of the Shadow being quite repugnant to Geometrical Demonſtration. His circular Hypotheſis Mr. *Horrox* (before I could perſuade him) aſſayed a long Time with indefatigable Pains and Study to correct, and amend; changing and turning them every way (ſtill amazed and amuſed with thoſe lofty Titles of Perpetuity and Perfection, ſo impudently impoſed upon them) until we found, by comparing Obſervations in ſeveral Places of the Orbs, that his Hypotheſes would never agree with the Heavens for all Times, as he confidently boaſts; no, nor ſcarce for any one whole Year together, alter the equal Motion, Proſthaphæreſes, and Excentricity howſoever you will.

‘ *Kepler*'s *Elliptick* is undoubtedly the Way which the Planets deſcribe in their Motions: And if you have read his *Comment. de motu* ♂^{is}, and his *Epit. Aſtron. Copern.* I doubt not you will ſay his Theory is the moſt rational, demonſtrative, harmonious, ſimple, and natural, that is yet thought of, (or I ſuppoſe can be;) all thoſe ſuperfluous Fictions being rejected by him, which others are forced ſo abſurdly to introduce. And although in ſome Reſpects his Tables be deficient, yet being once corrected by due Obſervations, they hold true in the reſt: Which *Lansberge*'s and all others want.

‘ Your Conceit of turning the Circle into 100,000,000 Parts, were an excellent one, if it had been ſet on foot, when Aſtronomy was firſt invented. Mr. *Horrox* and I have often conferred about it. But in reſpect that all Aſtronomy is already in a quite different Form, and the Tediousneſs of reducing the Tables of Sines, Tangents, and all other Things we ſhould have occaſion to uſe, into that Form; as alſo ſome Inconveniences, which we foreſaw would follow in the compoſing the Tables of Celeſtial Motions, together with the Greatneſs of the

‘ Innovation, deterred us from the Conceit. Only we intend to uſe ‘ the Centeſmes or Milleſmes of Degrees, becauſe of the Eaſe in Calculation. I have turned the *Rudolphine* Tables into Degrees and Milleſmes, and altered them into a far more conciſe, ready, and eaſy ‘ Form, than they are done by *Kepler*.

Foraſmuch as every Thing of Mr. *Crabtrie*'s is valuable, I have taken this Occaſion from my own Obſervations of the ſolar Spots (for the moſt Part drawn up near four Years ago) to give Mr. *Crabtrie*'s Letter at large (which I ſaw not till about a Month ago) containing as well ſome Things of another Nature, as what relates to the Spots; I have two other of his Letters concerning the Spots (with Mr. *Gaſcoigne*'s Anſwers.) One contains his Theory of their Motion and Appearances; the other his Way of obſerving them. But being long, I ſhall omit them for the preſent.

Fig. 115. *Shows the Stages and Lines deſcribed by the* Spots *upon the* Sun *in* Sept. *and* Novemb. 1706, *and in* Feb. *and* March, 170$\frac{6}{7}$, *and in* Sept. *and* Novemb. 1707.

Fig. 115.

Fig. 116. *Shows the Stages and Lines deſcribed by the* Spots *upon the* Sun *in* Jan. 170$\frac{4}{5}$, *and in* May, June, *and* Octob. 1705.

Fig. 116.

Eclipſe of the Sun, *June* 12, 1694, *in* New-England, *by* *Mr.* T. Brattle, n. 292. p. 1630.

XI. On the 12*th* of *June* 1694, in the Morning, I went to the College at *Cambridge*, about four Miles from *Boſton*, and obſerved with the Braſs Quadrant there, with Teleſcopick Sights, the Rays of the Sun being tranſmitted through one of the ſaid Sights, on a clean Paper, paſted on a plain Piece of Board, and faſtned at right Angles at about a Foot diſtance from the ſaid Sight, on which Paper I had drawn a Circle between 2 and 3 Inches Diameter, equal to the Sun's Diſk, and within that ſeveral Concentric Circles dividing the Diameter into 24 equal Parts, whereby I could obſerve to $\frac{1}{2}$ a Digit: The Room in which the Obſervation was made, was darkened with Blankets, and in order to render the Obſervation more exact (Mr. *Henry Newman* aſſiſting me all the while) I took the Altitude of the Sun with the foreſaid Quadrant, as followeth.

Obſervations made of the Sun's Altitude before the Eclipſe began, in order to rectify the Watch.

	By the Watch.				Comp. Altit.		Time by Calcul.			Differ.	
	h	′	″								
at	8	26	37	Mane	49	31	8	16	40	9	57
		31	27		48	26		21	40	9	47
		38	26		47	20		28	32	9	54

The Eclipſe was firſt perceived at 9h 25′ by the Watch, at which Time the Sun had ſcarcely been eclipſed 1 Minute, ſo that

By

	By the Watch.		True Time.		
	h	'	h	'	
At	9	24	9	14	It began
	9	32	9	22	about 1 digit eclipſed
	9	48	9	38	full 3 digits
	9	57¾	9	48	about 4
	10	06	9	56	near 5
	10	15	10	05	full 6
	10	33	10	23	about 8
	10	43	10	33	full 9
	10	47	10	37	full 9½
	10	53	10	43	full 10
	10	59	10	49	about 10½
	11	03	10	53	better than 10½
	11	06	10	56	much the ſame
	11	09	10	59	rather decreaſing
	11	10½	11	00½	ſenſibly decreaſed near ¼ of a digit
	11	14½	11	04½	neareſt to 10 digits
	11	25	11	15	full 9 digits, *i. e.* full 3 digits reſtored, or the Shadow rather within 9 digits
	11	29	11	19	8½ compleat
	11	34½	11	24½	full 8 digits
	11	44	11	34	full 7
	11	48	11	38	full 6 ½ digits
	11	52½	11	42½	juſt 6
	0	02½ P. M.	11	32½	juſt 5
	0	13	0	03	P. M. full 4
	0	26	0	16	full 2½
	0	32	0	22	better than 2
	0	41	0	31	better than 1
	0	48	0	38	ended.

Obſervations made after the Eclipſe was done, of the Sun's Altitude, in order to rectify the Watch.

	Time by the Watch				Comp. Altit.		True time.			Differ.	
	h	'	"								
At	3	31	30	P.M.	45	52	3	21	36	9	54
		36	15		46	23		26	16	9	59
		38	10		46	45		28	16	9	54
		46	50		48	19		36	48	10	02
		48	10		48	30		38	20	9	50

Hence it appears, that the Watch went about 10 Minutes too faſt during the whole Eclipſe, as we have all the Way allowed.

So that the Eclipſe

	h	′
Began at	9	14 Mane.
Ended	0	38 P. M.
Laſting in all	3	24.

Note, That in the Calculation, the Latitude of *Boſton* was allowed to be 42 . 25′.

Eclipſe of the Sun, *Nov.* 23. 1703. *in* New England, *by the* ſame, *ibid.* p. 1634.

XII. At half an Hour paſt Eight in the Morning, I ſet my Clock exactly by my Ring-Dial, and at half an Hour paſt Nine they nicely agreed, at

h ′
10 00 The Sun was not touch'd.
06 The Moon enter'd on the S. S. W. Point as near as I could judge.
15 The Eclipſe was conſiderably advanc'd.
20 Seem'd to be about half a Digit eclipſed, rather more than leſs, and the Section to be a ſmall Matter more Weſtwardly.
10 25 Much the ſame, and near the ſame Point.
30 Seem'd to be leſs.
33½ The Middle of the Section nearer the S. W. and the Diameter of the Section leſs every way.
37½ Much leſs and nearer the Weſt.
44½ It ended, and was juſt over, going off near the S. W. ſo that all the while it was within a Point or two of the Place where it firſt came on, or between the S. S. W. and the S. W.

I judg'd, when it was at the Height, that the Chord of the eclipſed Part was neareſt equal to the Side of an inſcrib'd Decagon, or ſubtended about 1/10 of the Periphery of the Sun's Disk.

I obſerv'd this Eclipſe with a Teleſcope of one Joint, 4 Foot and a half in Length, and had only two Glaſſes, ſo that it inverted the Object; and I had a red Glaſs, which ſuited it, ſo that I could ſcrew it in juſt before the Eye-Glaſs, and was not fain to hold it in my Hand, as when I obſerv'd the Sun's Altitude with the Braſs Quadrant, which was a great Convenience.

Eclipſe of the Sun, May 1/12. 1706. *at* Greenwich, *by Mr.* Flamſted, n. 306. p. 2237.

XIII. 1.] The Morning was cloudy and moiſt, till about Eight a Clock, when the Clouds began to break, and we had ſometimes a Sight of the Sun thro' the Spaces betwixt them. A ſeven-foot Teleſcope was fitted up with a Scene to receive the Species of the Sun caſt through it, and on which it was about ſeven Inches Diameter, divided into Digits by ſix concentrick Circles. But Clouds covering the Sun frequently rendred this way of obſerving inconvenient, and therefore laying aſide the *Apparatus* of the Scene, I viewed him through the Teleſcope with ſmoaked Glaſſes, to ſave my Eyes, and noted

Correct Time by the Pend. Clock. h	′	″	
8	21	30	A very ſmall Part of the ⊙ Diameter was eclipſed.
	28	00	The Chord of the Arch of the ⊙ Periphery eclipſed was 14′. 40″. then followed frequent Clouds through the Spaces betwixt; then ſome Zenith Diſtances of the Sun were taken for correcting the Clock, and afterwards near the Middle of the Eclipſe
9	21	46	The Parts of the Diameter remaining clear 5 00
	26	20	———— 4 30
10	31	50	Frequent large Clouds again, till the Sun appeared through the Breaks, and we ſaw the Eclipſe was not ended. Clouds again till
10	33	50	When the Sun ſhone out again, we ſaw his Limb intire, and the Eclipſe certainly over.

— at Canterbury, by Mr. S. Gray, *ibid.*

2.] Mr. *S. Gray* had prepared a Scene placed behind his ſeven Foot Glaſs, ſo that the Species of the Sun projected on it was ſeven Inches over; but having the ſame Sort of Weather that was at *Greenwich*, he ſaw not the Beginning, by reaſon of Clouds, but other Phaſes with the End he noted, as follows.

Correct Time by the Pend. Clock. h	′	
8	53	digits 5½ darkned
9	08	——— 7
	31	——— 10 or more
	36	——— The Sun ſhining for a ſhort Time, the Eclipſe ſeem'd to decreaſe.
	55	——— 7½ a little clearer,
	57	——— 6¾
10	02	——— 6
	04	——— 5¾
	14	——— 4
	16	——— 3¾
	20	——— 2½
	30	——— 1
	31	——— 0¾
10	36	½ The End accurately with a Tube of 16 Foot.

3.] Mr. *Abr. Sharp* caſt the Species of the Sun on a Scene-plate, behind his ſeven Foot Glaſs, ſo as it appeared ſeven Inches over. By reaſon of cloudy Weather, he ſaw neither the Beginning nor End: But other Phaſes near the Middle, as follows.

—*at* Horton *near* Bradford *in* Yorkſhire, *by Mr.* A. Sharp, *ibid.*

Time correct by the

h	′	″			
8	35	00	digits dark	3	by Ocular Eſtimation.
9	01	00	———————	7	
	4	54	———————	8 $\frac{3}{10}$	Eclipſed on the Scene.
	6	33	———————	8 $\frac{1}{2}$	
	7	53	———————	8 $\frac{6}{10}$	
	12	50	———————	9	
	16	08	———————	9 $\frac{4}{10}$	
	18	48	———————	9 $\frac{1}{2}$	exactly the ☉ ſhining out clear.
	20	45	———————	9 $\frac{1}{3}$	the ☉ ſtill ſhining clearly. Greateſt Obſcurity.
	21	48	———————	9 $\frac{1}{2}$	ſtill clear.
	28	46	———————	9	
	44	45	———————	7	
	54	42	———————	5 $\frac{1}{4}$	
10	06	10	———————	3 $\frac{1}{2}$	
	19	55	———————	1	preciſely.
	24	00	The ☉ ſeen thro' Clouds, the Eclipſe not ended.		
	30	00	The ☉ ſeen again perfectly round and intire.		

4.] Captain *Stannyan*, from *Bern* in *Switzerland*, writes 'That the 'Sun was totally darkned there for $4\frac{1}{4}$ Minutes of Time; that a fixed 'Star and a Planet appeared very bright; and that *his getting out of 'the Eclipſe was preceded by a Blood-red Streak of Light, from its Left 'Limb; which continued not longer than* 6 *or* 7 *Seconds of Time*; then 'Part of the Sun's Disk appear'd, all on a Sudden, bright as *Venus* 'was ever ſeen in the Night; nay, brighter; and in that very Inſtant 'gave a Light and Shadow to things, as ſtrong as Moon-light uſes 'to do.

— *at* Bern *in* Switzerland, *by Capt.* Stannyan, *ibid.*

The Captain is the firſt Man I ever heard of, that took Notice of a red Streak of Light preceding the Emerſion of the Sun's Body from a total Eclipſe: And I take Notice of it, becauſe it infers that *the Moon has an Atmoſphere*; and its ſhort Continuance of only 6 or 7 Seconds of Time, tell us, that *its Height is not more than the* 5 *or* 6 *hundredth Part of her Diameter.*

—*at* Geneva, *by Mr.* J. C. Facis *Duillier*, ibid.

5.] A little after the Sun's riſing, the Sky did ſeem clear; tho' the Air was thick already with ſome Vapours. Many little Clouds did afterwards ariſe here and there, and the Vapours did much increaſe. For want of a Pendulum Clock, in a convenient Place, the Moment of the *total* Immerſion, the Moment of the *firſt* Emerſion, and that of the *End* of the Eclipſe, could not be accurately obſerved. Tho' the Sky was ſomewhat overcaſt, the Heat of the Sun was already felt, when the Eclipſe did begin: But a very ſenſible Coldneſs took Place, as the Moon did by degrees cover a greater and greater Part of the Sun, and the Light decreaſe. The Eclipſe was obſerved only with ſome Glaſſes, either darkned with Smoak, or but little tranſparent; and by receiving the Sun's Image through a ſix Foot Teleſcope, which repreſented the Objects inverted, upon a white Paper, placed at ſome Diſtance, from the Eye-Glaſs. When the Sun was near being totally dark, the bright Creſcent, which did remain, was ſeen to diminiſh more and more, upon the Paper, where its Image was received. And when that Creſcent was reduced to a very narrow Breadth, and to a very little Length, it was ſeen on a Sudden to diſappear: And in that Moment the whole Sun was eclipſed. At the ſame Inſtant of Time, the Darkneſs, which was already very conſiderable, did become much greater. The Clouds did change on a Sudden their Colour, and became red, and then a pale Violet. There was ſeen, during the whole Time of the total Immerſion, a Whiteneſs, which did ſeem to break out, from behind the Moon, and to encompaſs it on all Sides equally. The ſame Whiteneſs was but little determined, in its outward Side, and was not broad the twelfth Part of the Diameter of the Moon. This Planet did appear very black, and her Disk very well defined, within the Whiteneſs, which encompaſſed it about, and whoſe Colour was the ſame with that of a white Crown, or *Halo*, of about four or five Degrees in Diameter, which accompanied it, and had the Moon for its Center. The Star of *Venus* was ſeen, at the ſame Time, at ſome Diſtance, without that Crown, between the Eaſt and N. E. in reference to the Sun. The Planets of *Saturn* and *Mercury* were ſeen alſo by many, Eaſtward from the Sun's Place. And if the Sky had been clear, many more Stars might have been ſeen, and with them the Planets of *Jupiter* and *Mars*; that towards the Eaſt, and this towards the Weſt: And ſo the ſeven Planets might have been ſeen, almoſt all at once. Accordingly ſome Gentlewomen being in the Country, did tell, as it is ſaid, more than ſixteen Stars. And many People, which were on the Neighbouring Mountains, did ſee the Sky ſtarry, in ſome Places, where it was not overcaſt, as during the Night, in the Time of the full Moon. The total Emerſion did begin about three Quarters paſt Nine. The Duration of the total Darkneſs was preciſely three Minutes, or 180 Seconds, to the Moment that the firſt Ray of the Sun did begin to appear again, with much

Brightneſs. And this Time was obſerved, with a ſimple Pendulum; which was afterwards compared with a Pendulum Clock, ſhewing the Seconds, and regulated upon the mean Motion of the Sun. A little after the Sun had begun to appear again, the Whiteneſs and the Crown, which did encompaſs the Moon, did entirely vaniſh. The Sun did then ſhew itſelf more and more; appearing at firſt as a little Creſcent, which did ſtill encreaſe; and whoſe concave Side did ſeem terminated, as by an Arch deſcribed with the Compaſs. A little before the total Obſcuration, the Country, on the Weſt-ſide, did already ſeem overcaſt with Darkneſs; and after the total Obſcuration, the Darkneſs was ſeen to leave us more and more, and to fly Eaſtward. According to Mr. Profeſſor *Gautier*'s Obſervations, from the firſt Emerſion of the Sun, to the End of the Eclipſe, there was $1^h\ 9'\ 30''$. As to the accurate Times they are uncertain, the Pendulum Clock having been ſet only by a ſmall Sun-Dial. I ſend you alſo the following Account, which the ſame Gentleman did communicate to me.

	h	′	″
6.] ' At *Marſeilles* the Eclipſe did begin at	8	28	40
' It did reach the Sun's Center at	9	6	11
' It was total at	9	34	15
' The Sun did begin to appear again at	9	37	9
' The Eclipſe did come again to the Center at	10	12	23
' It did entirely end at	10	47	50

— *at* Marſeilles *by Mr.* Chazelles, *and Father* Laval, *ibid.*

' Three Stars were diſtinctly ſeen; and during three Minutes it was ' not poſſible to read. And there did remain one bright Digit, all ' about the Globe of the Moon.

The Manor-Houſe of *Duillier* is in the Latitude of 46° 24′. In Longitude it is 4° 13′ 45″ to the Eaſtward of the *Royal Obſervatory* at *Paris*. And St. *Peter*'s Church at *Geneva* is, in Latitude, 0° 12′ to the Southward, and in Longitude, 0° 5′ 2″ to the Weſtward of *Duillier*.

Before I make an End, I muſt take Notice, that, according to theſe Obſervations, the Altitude of the Moon's Atmoſphere cannot well be ſuppoſed leſs than of 130 Miles in perpendicular Height: Of which Miles 60 go to one Degree of Earth. Neither could that Atmoſphere be diſcovered before the Time of this Eclipſe, by any Refraction of the Stars; probably becauſe of this Refraction's Smallneſs, and for Want of proper Obſervations. And though it was very plain that the Atmoſphere of the Moon muſt needs ſhew itſelf in the Time of a total Eclipſe of the Sun; yet I do not know that any Body did think of this, till, in the laſt Month of *May*, many Perſons did actually ſee it.

Some particular Obſervations, which are intended to be made publick, do evince that our Atmoſphere is ſometimes viſible, all along, from the Surface of the Earth to the perpendicular Height of one Semidiameter of the Terreſtrial Globe. And the continued Appearance of a Crown, of only four or five Degrees Diameter, about the Sun, during the whole Time of the total Obſcuration, does ſhew, that the Æthereal Matter, in which that Crown was produced, muſt be at a very great Height above the Surface of the Earth. But if that Crown was to be ſeen, ſo far as the Weather did permit, in all the Places where the Eclipſe was total, it muſt be concluded, that the Cauſe of it was not in our Air, but in ſome Vapours encompaſſing the Sun: And probably, in thoſe very Vapours, which produce that pointed Light, that has been obſerved lying in a Manner along the Ecliptick, and that has the Sun for Center. Now either of theſe Concluſions, *viz.* concerning the great Height of the Parts of our Atmoſphere, capable of producing that Crown, or elſe concerning a Meteor obſerved, not in our Air, but in the Vapours that encompaſs the Sun, is very ſingular, and deſerves a great deal of Attention. If ever ſuch another Appearance ſhould be ſeen, in the Time of a total Eclipſe, it would be proper to obſerve accurately the leaſt Diameter of the Crown, from Inſide to *Inſide:* And to take Notice, whether, during the whole Time of the total Immerſion, the inward Circle be every where continued, and of an uniform Figure. The leſs the ſaid Diameter, and the greater the Exceſs of the Moon's apparent Diameter above that of the Sun; as alſo the greater the apparent Altitude of the Sun is above the Horizon, the higher the Cauſe, which produces the Crown, muſt be above the Surface of the Earth. And the Poſition upon the Moon's Disk, in Reference to the Zenith, of the Points of Contact, where the Sun diſappears, or begins to ſhew itſelf again, is here alſo of ſome Conſideration.

— at Zurich, *by Dr.* J. J. Scheuchzer.

7.] We have had here, *May* 12. both a total and Annular Eclipſe of the Sun; total, becauſe the whole Sun was cover'd by the Moon; Annular, though not properly ſo called, but by Refraction, for a ruddy Brightneſs appear'd about the Moon, ariſing from the Rays refracted by the Moon's Atmoſphere.

Fig. 119.

The Beginning of the Eclipſe was in the Morning $8^h.$ 54′.
The Middle 9. 58′.
The End 11. 12′.
The Mora of the mean and full Obſcuration 4′.

Both the fixt Stars and Planets might be ſeen. The Birds betook themſelves to their Neſts. The Bats came out of their Holes, and the Fiſhes ſwam upon the Water. We ourſelves perceived a ſenſible Degree of Cold, and the Dew fell down upon the Plants.

XIV. The

Eclipſe of the Sun, *Sept.* 3. 1708. *at* Upminſter, *by Mr.* Derham, n. 320. p. 312.

The Corr. App. Time			
			XIV. The Beginning of the Eclipſe we could not ſee for Clouds.
h	′	″	
6	44	15	The Sun peeped out of the Clouds, and I judged, by my Eye, that about one Tenth of a Digit was eclipſed.
			Then Clouds nearly all the Time of the Eclipſe. But at
8	31	15	A little Obſcuration appeared through the Teleſcope.
8	32	45	A *very* little Obſcuration through the Teleſcope.
			Then Clouds. And at
8	35	45	We could diſcern no Remains of the Eclipſe through the Teleſcope.

From theſe Obſervations I imagine the End of this Solar Eclipſe was much about 8 h. 33′ in the Morning.

Obſervations of the Total Eclipſe *of the* Sun, *April* 22. 1715, *at* London, *by Dr.* E. Halley, n. 343. p. 245.

XV. 1. Though it be certain from the the Principles of Aſtronomy, that there, happens neceſſarily a Central Eclipſe of the Sun, in ſome Part or other of the Terraqueous Globe, about twenty-eight Times in each Period of eighteen Years; and that of theſe, no leſs than Eight do paſs over the Parallel of *London*, three of which eight are total with Continuance: Yet, from the great Variety of the Elements, whereof the *Calculus* of Eclipſes conſiſts, it has ſo happened, that ſince the 20th of *March*, *Anno Chriſti* 1140, I cannot find that there has been a total Eclipſe of the Sun ſeen at *London*, though in the mean Time the Shade of the Moon has often paſt over other Parts of *Great Britain*.

Having found, by comparing what had been formerly obſerved of Solar Eclipſes, that the whole Shadow would fall upon *England*, I thought it a very proper Opportunity to get the Dimenſions of the Shade aſcertained by Obſervation; and accordingly I cauſed a ſmall Map of *England*, deſcribing the Track and Bounds thereof, to be diſperſed all over the Kingdom, with a Requeſt to the Curious to obſerve what they could about it, but more eſpecially to note the Time of Continuance of total Darkneſs, as requiring no other Inſtrument than a *Pendulum Clock*, and as being determinable with the utmoſt Exactneſs, by reaſon of the momentanous Occultation and Emerſion of the luminous Edge of the Sun, whoſe leaſt Part makes Day. Nor did this fail of the deſired Effect, for the Heavens having proved generally favourable, we have received from ſo many Places ſo good Accounts, that they fully anſwer all our Expectations, and are ſufficient to eſtabliſh ſeveral of the Elements of the *Calculus* of Eclipſes, ſo as for the Future we may more ſecurely rely on our Predictions: Though it muſt be granted, that in this our Aſtronomy has loſt no Credit.

Having received the Orders of the Society to provide for the Obſervation to be made at their Houſe in *Crane-Court*, I procured a *Quadrant* of near 30 Inches *Radius*, exceedingly well fixt with Teleſcope Sights, and moved with Screws, ſo as to follow the Sun with great Nicety; as alſo a very good *Pendulum Clock* well adjuſted to the mean Time, and ſeveral Teleſcopes to accommodate the other Obſervers.

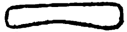
In order to examine both Clock and Quadrant, I, on the 20th of *April*, obſerved the Diſtance of the upper Limb of the Sun from the Zenith 36° 16′, and the next Day 35°. 58′; by which it appeared, that the Diſtances from the *Zenith*, taken by this Quadrant, ought to be increaſed by about one Minute: And that Allowance being made, by many Obſervations taken before and after Noon on the ſaid 21ſt Day, the Clock was found to anſwer the apparent Time or Hour of the Sun with ſufficient Exactneſs, as not going above 10″. too faſt. The next Day, *April* 20°, juſt before the Eclipſe began, we took the Diſtances of the Sun, from the Zenith, *viz.* at 7^{h}. 42′. 52″ A. M. the correct Diſtance of the Sun's Center *à vertice* was 62°. 1′. 40″. at 7^{h}. 45′. 48″. it was 61°. 34′. 40″. And again at 7^{h}. 48′, 55″ it was 61°. 6′. 40″: Which, with the given Declination of the Sun and Latitude of the Place, ſhew the true Times reſpectively to have been 7^{h}. 42′. 38″, 7^{h}. 45′. 35″. and 7^{h}. 48′. 39″; all agreeing, that the Clock was only 14 Seconds too faſt, and had gained ſcarce any Thing ſenſible in a Day's Time: So that it might be entirely depended upou during the Continuance of the Eclipſe.

Having computed that the Eclipſe would begin at 8^{h}. 7′, I attended ſoon after Eight, with a very good Teleſcope of about ſix Foot, without ſtirring my Eye from that Part of the Sun whereat the Eclipſe was to begin: And at 8^{h}. 6′. 20″. by the Clock, I began to perceive a ſmall Depreſſion made in the Sun's Weſtern Limb, which immediately became more conſpicuous; ſo that I concluded the juſt Beginning not to have been above five Seconds before, that is, exactly at 8^{h}. 6′. 00″. correct Time.

From this Time the Eclipſe advanced, and by Nine of the Clock was about ten Digits, when the Face and Colour of the Sky began to be changed from perfect ſerene azure Blue, to a more dusky livid Colour, having an Eye of Purple intermixt, and grew darker and darker till the total Immerſion, which happen'd at 9^{h}. 9′ 17″ by the Clock, or 9^{h}. 9′. 3″ true Time. This Moment was determinable with great Nicety, the Sun's Light being extinguiſh'd at once; and yet more ſo was that of the Emerſion, for the Sun came out in an Inſtant with ſo much Splendor, that it ſurprized the Beholders, and in a Moment reſtored the Day, *viz.* at 9^{h}. 12′. 26″. true Time, after he had been totally obſcured for 3′. 23″ of Time. And as near as I could eſtimate the Points on the Moon's Limb, where the laſt Particle of the Sun vaniſhed was about the Middle of the *South Eaſt* Quadrant of her Limb, or about 45 Degrees from her *Nadir* to the Left-hand: And the firſt Emerſion was about ten Degrees below the Horizontal Line through the Moon's

Center on the Weſt-ſide and at 14 Minutes paſt Nine, correct Time, I judged the Horns of the Eclipſe to have been exactly perpendicular; and by Conſequence, the Centers of the Sun and Moon to be in equal Altitude.

It was *univerſally* obſerved, that when the laſt Part of the Sun remained on his Eaſt-ſide, it grew very faint, and was eaſily ſupportable to the naked Eye, even through the Teleſcope, for above a Minute of Time before the total Darkneſs; whereas on the contrary, my Eye could not endure the Splendour of the emerging Beams in the Teleſcope from the firſt Moment. To this perhaps two Cauſes concurred; the one, that the Pupil of the Eye did neceſſarily dilate itſelf during the Darkneſs, which before had been much contracted by looking on the Sun. The other, that the Eaſtern Parts of the Moon, having been heated with a Day near as long as thirty of ours, muſt of Neceſſity have that Part of its Atmoſphere replete with Vapours, raiſed by the ſo long continued Action of the Sun; and by conſequence, it was more denſe near the Moon's Surface, and more capable of obſtructing the Luſtre of the Sun's Beams. Whereas at the ſame Time the Weſtern Edge of the Moon had ſuffered as long a Night, during which there might fall in Dews all the Vapours that were raiſed in the preceding long Day; and for that reaſon, that Part of its Atmoſphere might be ſeen much more pure and tranſparent.

About two Minutes before the total Immerſion, the remaining Part of the Sun was reduced to a very fine Horn, whoſe Extremities ſeemed to loſe their Acuteneſs, and to become round like Stars. And for the Space of about a Quarter of a Minute, a ſmall Piece of the Southern Horn of the Eclipſe ſeemed to be cut off from the reſt by a good Interval, and appeared like an oblong Star rounded at both Ends, in this Form : Which Appearance could proceed from no other Cauſe, but the Inequalities of the Moon's Surface, there being ſome elevated Parts thereof near the Moon's Southern Pole, by whoſe Interpoſition, Part of that exceedingly fine Filament of Light was intercepted.

A few Seconds before the Sun was totally hid, there diſcovered itſelf round the Moon a luminous Ring, about a Digit or perhaps a tenth Part of the Moon's Diameter in Breadth. It was of a pale Whiteneſs, or rather Pearl Colour, ſeeming to me a little tinged with the Colours of the *Iris*, and to be concentrick with the Moon; whence I conclude it the Moon's Atmoſphere. But the great Height of it, far exceeding that of our Earth's Atmoſphere; and the Obſervations of ſome who found the Breadth of the Ring to increaſe on the Weſt-ſide of the Moon, as the Emerſion approached; together with the contrary Sentiments of thoſe, whoſe Judgment I ſhall always revere, makes me leſs confident, eſpecially in a Matter whereto I gave not all the Attention requiſite.

Whatever it was, this Ring appeared much brighter and whiter near the Body of the Moon, than at a Diſtance from it; and its outward Circumference, which was ill defined, ſeemed terminated only by the extreme Rarity of the Matter it was compoſed of; and in all Reſpects reſembled the Appearance of an enlightned Atmoſphere viewed from far: But whether it belonged to the Sun or Moon, I ſhall not at preſent undertake to decide.

During the whole Time of the total Eclipſe, I kept my Teleſcope conſtantly fixt on the Moon, in order to obſerve, what might occur in this uncommon Appearance, and I ſaw perpetual Flaſhes or Coruſcations of Light, which ſeemed for a Moment to dart out from behind the Moon, now here, now there, on all Sides, but more eſpecially on the Weſtern Side, a little before the Emerſion: And about two or three Seconds before it, on the ſame Weſtern Side, where the Sun was juſt coming out, a long and very narrow Streak of a dusky, but ſtrong red Light, ſeemed to colour the dark Edge of the Moon, though nothing like it had been ſeen immediately after Immerſion. But this inſtantly vaniſhed upon the firſt Appearance of the Sun, as did alſo the aforeſaid luminous Ring.

As to the Degree of Darkneſs, it was ſuch, that one might have expected to have ſeen many more Stars than were ſeen at *London*: The three Planets, *Jupiter*, *Mercury* and *Venus* were all that were ſeen by the Gentlemen of the Society from the Top of their Houſe, where they had a free Horizon: And I do not hear that any one in Town ſaw more than *Capella* and *Aldebaran* of the fixed Stars. Nor was the Light of the Ring round the Moon capable of effacing the Luſtre of the Stars, for it was vaſtly inferior to that of the full Moon, and ſo weak, that I did not obſerve it caſt a Shade. But the under Parts of the Hemiſphere, particularly in the *South Eaſt* under the Sun, had a crepuſcular Brightneſs; and all round us, ſo much of the Segment of our Atmoſphere as was above the Horizon, and was without the Cone of the Moon's Shadow, was more or leſs enlightned by the Sun's Beams; and its Reflection gave a diffuſed Light, which made the Air ſeem hazy, and hindred the Appearance of the Stars. And that this was the real Cauſe thereof, is manifeſt by the Darkneſs being more perfect in thoſe Places, near which the Center of the Shade paſt, where many more Stars were ſeen, and in ſome, not leſs than twenty, though the Light of the Ring was to all alike.

During the Time whilſt the Sun recovered his Light, ſeveral Altitudes were taken to examine the Regularity of the Clock's Motion, and tho' the Sun now roſe much ſlower than at the Beginning, yet they all conſpired within a very few Seconds, that the Clock went ſtill one Quarter of a Minute too faſt. And the End of the Eclipſe approaching, I attended the Moment thereof, with all the Accuracy I could, and concluded the complete Separation of the Sun and Moon at $10^{h}.\ 20'.\ 15''$ by the Clock, or exactly $10^{h}.\ 20'$ correct Time.

Hitherto I exhibit only what myſelf ſaw, but there were with us a great many Members of the Society; and the Right Honourable the *Earl of Abingdon*, and the Lord Chief Juſtice *Parker* were of the Number: The latter of which ſhewed an uncommon Curioſity and Deſire of Exactneſs, his Lordſhip doing us the Honour to aſſiſt at moſt of the Obſervations made for determining the Error of the Clock, and did himſelf, at the Moment of the Emerſion from total Darkneſs, obſerve the Diſtance of the Planet *Jupiter* from the Zenith 48°. 29′. by which the Time thereof is verified.

There were alſo preſent ſeveral Gentlemen of other Nations, and among them Monſieur *le Chevalier de Louville* and Mr. *Moumort*, both of them Members of the *Royal Academy* of *Sciences* at *Paris*: The firſt whereof came purpoſely to obſerve this Eclipſe with us, and having ſeen the Beginning applied, himſelf to take Digits with his Micrometer, and to obſerve the Occultations of three Spots at that Time ſeen in the Sun; and communicated the following Notes, *viz.*

	h	′	″	
At	8	28	20	Four Digits were eclipſed.
	8	32	57	The firſt and bigger Spot touched the Moon.
	8	33	18	The ſame was wholly hid.
	8	34	08	The firſt of the two leſſer Spots was hid.
	8	34	58	The ſecond of them was hid.
	9	36	01	Emerſion of the greater Spot.
	9	38	06	Emerſion of the firſt leſſer Spot.
	9	40	25	Emerſion of the ſecond leſſer Spot.
	10	20	04	The End of the Eclipſe.

And he determined the Time of the total Darkneſs 3′. 22″, or one Second leſs than by my Account.

The Heavens were all the while very favourable to us, and there was very little or no Wind, and not ſo much as one Cloud interrupted our View from the Beginning to the End; but no ſooner was the Eclipſe over, but a great Body of Clouds hid the Sun for many Hours after.

Theſe Obſervations having been made with all the Care we could, are not, 'tis hoped, far from the Truth.

What we have received from other Places is as follows:

The Reverend Mr. *James Pound*, Rector of *Wanſted* in *Eſſex*, gives the following Account of the principal Phænomena obſerved there; he being furniſhed with very curious Inſtruments, and well ſkilled in the Matter of Obſervation, and having rectified his Clock by ſeveral Altitudes of the Sun taken both before and after, *viz.*

	h.	′	″	
At	8	6	37	The Eclipſe firſt perceived.
	9	9	28	The total Immerſion.
	9	12	48	The Emerſion.
	10	20	32	The juſt End of the Eclipſe.
	0	3	20	The Continuance of total Darkneſs.

The near Agreement of this Obſervation with our own (the Difference being only what is due to the Difference of the Meridians) makes us the leſs ſolicitous for what was noted at the *Royal Obſervatory* at *Greenwich*; from whence we can only learn, that the Duration of total Darkneſs was 3′. 11″.

The Reverend Mr. *William Derham*, Rector of *Upminſter* in *Eſſex*, aſſiſted by *Samuel Molineux*, Eſq; Secretary to his *Royal Highneſs* the *Prince*, and other Perſons of Quality, made the following Obſervations there, *viz.*

	h.	′	″	
At	8	7	41	The Eclipſe began.
	8	33	46	The Moon touched the greater Spot.
	8	34	36	She touched the middle Spot.
	8	35	41	She touched the third Spot.
	9	10	58	The total Darkneſs began on a ſudden, and *Aldebaran* appeared.
	9	14	6	The Emerſion, or the End of total Darkneſs.
	0	3	8	Continuance of total Darkneſs.
	9	42	41	The third and laſt Spot diſcovered.
	10	21	45	The End of the Eclipſe, by a 13½ Foot Glaſs.

And a little before the Beginning of the Eclipſe, he found the greater and preceding Spot to be more Northerly than the Sun's Center 373½ ſuch Parts as the Sun's Diameter was 1647, and that it followed his Weſtern Limb 0′. 43″ of Time: By which *Data* the Situation of that Spot is well determined.

The Profeſſors of Aſtronomy in both Univerſities were not ſo fortunate: Dr. *Keill*, by reaſon of Clouds, ſaw nothing diſtinctly at *Oxford*, but the End, which he obſerved at 10^h. 15′ 10″. As to the total Darkneſs, he could only eſtimate it by the ſudden Change of the Light of the Sky; and reckoned its Continuance but 3′. 30″; which was certainly too little, the Center of the Shadow having without doubt paſt very near *Oxford*. And the Reverend Mr. *Cotes* at *Cambridge*, had the Miſfortune to be oppreſt by too much Company; ſo that though the Heavens were favourable, yet he miſs'd both the Time of the Beginning of the Eclipſe, and that of total Darkneſs. But he obſerved the Occultations of the three Spots, *viz.* of the firſt and greateſt at 8^{h}. 34′. 11″. of the ſecond at 8^{h}. 35′. 15″. and of the laſt at 8^{h}. 36′. 55″. He noted alſo the End of total Darkneſs at 9^{h}. 14′. 37″, and the exact End of the Eclipſe at 10^{h}. 21′. 57″.

We have received ſeveral Accounts from ſome Places, which lay near the Track of the Center of the Shade, and which might have been very proper to determine the greateſt Continuance of the Darkneſs; as from *Plymouth*, *Exeter*, *Weymouth*, *Daventry*, *Northampton* and *Lynn-regis*, all agreeing that the whole Sun was obſcured at thoſe Places full four Minutes, and ſome of them rather more. But as theſe Obſervers give us no Account how they meaſured this Time, it may well be ſuppoſed they took it in a round Number, and perhaps from Pocket Minute-Watches. What I think may beſt be relied on for this Purpoſe, are two correſponding Obſervations made, the one at *Barton* near *Kettering* in *Northamptonſhire*, where by the Obſervation of *John Bridges*, Eſq; Treaſurer of his Majeſty's Revenue of Exciſe, with a good Pendulum Clock and all due Care, the whole Sun was hid no more than 3′. 53″. The other was by Mr. *John Whiteſide*, A. M. Keeper of the *Aſhmolean Muſeum* at *Oxford*, and a ſkilful Mathematician, who obſerved after the ſame Manner, at *King's Walden* in *Hertfordſhire* near *Hitchen*, that the total Eclipſe continued but 3′. 52″. Hence it follows, that the Center of the Shade paſt near the Middle between theſe two Places, which are but 30 Geographical Miles diſtant from one another, and ſituate near at right Angles to the Way of the Shade, and therefore that the total Obſcurity, where longeſt, could laſt but about 3′. 57″, or perhaps a Second or two more at *Lynn*, and leſs at *Plymouth*, the Velocity of the Progreſs of the Shade gradually decreaſing, and its Diameter increaſing as it paſt on to the Eaſtward. And this Situation of the middle Line is confirmed by an Obſervation made at the Seat of the Right Honourable the Lord *Foley* at *Witley*, eight Miles beyond *Worceſter*, by his Order, and communicated by his Lordſhip to the Society; whereby it appears, that the total Darkneſs laſted there 3′. 15″. Hence it follows that *Witley* was about three or four Miles farther from the Center of the Shade on the North-ſide than *London* on the South: And *Witley* being, by *Ogilby*'s Menſuration, 118 Meaſured Miles from *London*, it is plain that the Center paſt over *Iſlip*, which is, by the ſame Admeaſurement, 57 ſuch Miles on that Road, and about five Miles almoſt due North from *Oxford*; ſo that the Center of the Shade left *Oxford* but very little upon the Right-Hand. This Situation agrees perfectly well with the former between *Barton* and *King's Walden*, and as far as the Geography of our Country may be depended on, I conclude the Center to have entred upon *England* about *Plymouth*, and to have paſt over *Exeter*, the *Devizes*, *Iſlip*, *Buckingham*, and *Huntington*, leaving *Oxford* and *Bedford* on the Right, and *Lynn* on the Left, and to have quitted the Coaſt of *Norfolk* about *Wells* and *Blakeney*.

As to the Southern Limit or Term, where the Eclipſe ceaſed to be total on the South-ſide of the Sun, we have received an Account of an Obſervation made at *Norton-court*, about Ten Miles on this Side *Canterbury*, by the Reverend Dr. *Harris*, aſſiſted by that accurate Obſerver Mr. *Stephen Gray*, by which we learn that the Eclipſe began there at $8^{h}.\ 8'.\ 55''$. and ended at $10^{h}.\ 24'.\ 47''$; and that the total Darkneſs continued but about one Minute or rather leſs, the Middle thereof being at $9^{h}.\ 13'.\ 52''$. From this Duration it will follow, that *Norton-court* was but about three or four Miles within the Shade. And that it was really ſo, is confirmed by the Relation of the Inhabitants of *Boſton*, about Midway between *Norton-court* and *Canterbury*, who aſſured Mr. *Gray*, that the Eclipſe was not total there, but, as one of them expreſt it, before the Sun had quite loſt his Light on the Eaſt-ſide, he recovered it on the Weſt: And that there was a ſmall Light left on the lower Part of the Sun that appeared like a Star. And from *Cranbrook* in *Kent* we are informed, by the Relation of *William Tempeſt*, Eſq; that he obſerved there the Sun to be extinguiſhed but for a Moment, and inſtantly to emerge again: So that the Limit paſt exactly over this Town, which is about 38 Geographical Miles from *London*, and very near the right Angle, where the Perpendicular from *London* falls on the Line of the Limit, being $3'.\ 00''$ of Time to the Eaſtward of *London*, in the Latitude of $51^{\circ}.\ 6'$, as near as I can gather.

How it paſt over *Suſſex* we have no authentick Relations, but have learnt that it was total at *Wadhurſt* beyond *Tunbridge-wells*, as alſo for ſome ſhort Time at *Lewis*; but that it was not ſo at *Brightling*, which Place being ſituated on an Eminence, all the Country to the Northward was ſeen in Darkneſs, whilſt they there had ſome Benefit of a ſmall Remainder of the Sun.

From theſe Obſervations we may conclude, that this Limit came upon the Coaſt of *England*, about the Middle between *Newhaven* and *Brighthelmſton* in *Suſſex*, and paſſing by *Cranbrook* and *Boſton*, about four Miles on the Right-hand, quitted the Coaſt of *Kent* not far from *Hern* toward the ancient *Regulbium*, now called *Reculver*. So that ſcarce one third Part of *Kent*, and not ſo much of *Suſſex*, out of all the South Coaſt of *Great-Britain*, eſcaped being involved in this Darkneſs.

The Northern Limit, having paſt over a much greater Space, has had more Obſervers, and is not leſs curiouſly determined than the other. By the Account given by the Reverend Mr. *Roger Proſſer*, Rector of *Haverford-Weſt*, the Eclipſe was total there a Minute and a half; whence it follows, that *Haverford* was but about 6 Miles within the Shade, and therefore that it entred on *Pembrokeſhire* about the Middle of St. *Bride*'s Bay, leaving St. *David*'s and *Cardigan* on the left Hand; and having traverſed thoſe two Counties and *Montgomeryſhire*, it entred

Shropſhire, leaving the Town of *Shrewsbury* $1'.40''$ in the Shadow, as was obſerved there by Dr. *Hollings*; whereby it appears that *Shrewsbury* was about 8 Miles within the Limit. Thence it proceeded by the Eaſt-ſide of *Cheſhire*, leaving *Whitchurch* and *Nantwich* a very little without, and paſſing by *Congleton*, went over the *Peak* of *Derbyſhire* into *Yorkſhire*, and croſs'd the great Northern Road between *Pontefract* and *Doncaſter*, ſomewhat nearer the former than the latter. For by the Obſervations of *Theophilus Shelton*, Eſq; at *Darrington*, about two Miles on this Side *Pontefract*, (in Lat. $53^\circ.40'$ and Long. Weſt from *London* $4'.40''$. of Time, as may be concluded from *Norwood*'s Meaſure of a Degree) the Sun at $9^h.11'$. was reduced almoſt to a Point, which both in Colour and Size reſembled the Planet *Mars*; but while he watched for the total Eclipſe, that Point grew bigger, and the Darkneſs diminiſhed; whence he argued the Limit to have been very little more Southerly. And ſince has been informed, that it was juſt total in *Barnſdale*, three Miles South from thence. And that it was ſo at *Badſworth*, about the ſame Diſtance from *Darrington*, we are told by a Letter of the Reverend Mr. *Daubuz*, that he has a certain Account from that Place, that the luminous Ring round the Moon was ſeen there, which was no where viſible but while the Eclipſe was total. From theſe *Data* we may ſecurely determine the Remainder of this Track, and that the Edge of the Shadow, having paſt over the reſt of *Yorkſhire*, paſſed off to Sea about *Flamborough* Head.

So that of the forty Counties, into which *England* is ſubdivided, only the five moſt Northerly have not had the Sun wholly hid from them; and ſix others have eſcaped but in Part, *viz.* *Shropſhire*, *Cheſhire* and *Yorkſhire*, and the extreme Part of *Derbyſhire* on the *North*, and *Kent* and *Suſſex* on the *South*; all the reſt of the Kingdom having more or leſs ſuffered an Interval of total Darkneſs.

I ſhall not at preſent conſider this Eclipſe as univerſal, but only as it related to *England*; and it ſhall ſuffice to ſay, that the Shadow came out of the *Atlantick* Ocean, having paſt over the Iſlands *Azores*; and that the Southern Limit of it reach'd the Iſle of *Uſhant*, and the North-weſt Coaſts of *Britanny* between *Breſt* and *Morlaix*; and dividing our Iſlands of *Guernſey* and *Jerſey*, juſt touched upon the Promontory of *Normandy* called *Cape de Hague*. And that after it had quitted *England*, and traverſed the *German Ocean*, it fell on *Jutland* on the South-ſide, and *Norway* on the North; and thence proceeded to the Eaſtward over *Sweden*, *Finland*, &c.

It remains now to conſider the Figure, Poſition, Direction, Velocity and Magnitude of the Shadow as it paſſed over us. As to the Figure, 'tis obvious that the Shadow of the Moon being a Cone, and the Earth's Surface ſufficiently Spherical, the apparent Shadow on the Earth will be the common Interſection of a Cone and Sphere, which is a Figure hitherto little conſidered by Geometers; and not being *in Plano*, is not to be exactly deſcribed but in the ſpherical or conical Surface. How to find the Points of this Curve, in all Caſes, is ſhewn by *P. Couſier*, in a very ſcarce *Latin* Book printed at *Dijon* in *Burgundy*, and publiſhed at *Paris* in the Year 1663: Nor do I know of any other Author, that has handled the ſame Subject ſince, though capable and worthy of further Improvement. By what he there delivers, *Prop*. 11, 12. *Lib*. I. it will be eaſily underſtood, that the Convexity of ſo ſmall a Part of the Earth's Surface, as the Shadow commonly occupies, can produce only an inconſiderable Effect; ſo that without ſenſible Error we may take it for a Plane, and the Section for a true *Apollonian Ellipſis*, whoſe tranſverſe *Axis*, by reaſon of the Smallneſs of the Angle of the Cone, will be to its Conjugate nearly as *Radius* to the Sine of the Sun's Altitude at its Center, eſpecially if he be conſiderably elevated. But when he is near the Horizon, it will be neceſſary to have Regard to the true Figure, by reaſon of the great Length, to which the tranſverſe Axe is extended, and particularly when the Shade is entring upon, or leaving the Earth's Disk.

As to the Poſition of the *Axis* of the Shadow, it is manifeſt, that it muſt always lie in the Plane of a great Circle of the Earth, paſſing through the *Axis* of the Cone of the Shade; and therefore all that is required, is, to obtain the Azimuth and Altitude of the Sun, at the Place where the Center of the Shade at any Time is found, to determine the Situation of the Axe and *Species* of the Ellipſe required. Thus the Middle of the Eclipſe at *London* having been obſerved at 9^{h}. 10′. 45″, by the given Latitude and Declination, we find his Azimuth about 59°. 00′. and Altitude 40°. 46′. that is juſt 40 Degrees high, at the Center of the Shadow. Wherefore the tranſverſe Axe of the Ellipſe was to its Conjugate very near as *Rad.* to the *Sine* of 40°, or as 1000 to 643 *proximè*; and did make an Angle of 59°, or very little more, with the Meridian paſſing at that Time through the Center of the Shade.

The Direction and the Velocity of the Motion, wherewith the Center of the Shade paſt over *England*, is next to be conſidered, wherein it is to be obſerved, that the Shadow paſſes in a very compound Curve, which as the former is not *in Plano*, and only deſcribable on the Surface of the Sphere: Nor is its Motion equable, but compounded of very many Elements, producing a great Variety. By what Method its Points, and its Tangents in thoſe Points, are to be obtained, I reſerve to another Opportunity; only I obſerve, that for ſo ſmall a Part of the Curve, as went over *England*, it may be eſteemed a right Line, with more Exactneſs than we uſually find in moſt of our Geographical Charts. And the ſame may be ſaid for the Velocity, which, though in our preſent Inſtance, it was continually decreaſing, may, for ſo ſhort a Time, be ſuppoſed to have been the ſame without ſenſible Error.

By a careful Calculation, I have determined the Velocity of the Motion, at the Time of the Middle of the Eclipſe at *London*, to have been 29 Geographical Miles in a Minute of Time *quam proximè:* And that its Way made an Angle of 52°. 45′. with the Meridian towards the Eaſtwards of the North; wherefore the ſaid Way made an Angle with the Axis of the Ellipſis of 68°. 15′. And the greateſt Duration of total Darkneſs having been 3′. 57″, it will follow, that that Diameter of the Elliptick Figure, according to which the Shade paſt, was no leſs than 114½ Geogr. Miles. And from the Elements of the Conicks 'tis eaſy to be proved, that ſuppoſing the Figure of the Shade a true Ellipſe, whoſe Axes are as *Radius* to the *Sine* of 40 Degrees, the greater Axis would be 171 Geographical Miles, and the leſſer 110; and the neareſt Diſtance between the Limits ſuppoſed Parallel 164 ſuch Miles.

And this Length of the *Axis* of the Shade, derived purely from the Duration of total Darkneſs, is fully confirmed by the obſerved Diſtance of the parallel Limits; the one paſſing by *Badſworth* in *Yorkſhire*, the other by *Cranbrook* in *Kent*. For by the two Latitudes 53°. 37′ and 51°. 6′, with the Difference of Longitude 7′. 40″. of Time, or 1°. 55′, the Diſtance of theſe two Places is given 166½ Geogr. Miles; with the mean Angle of Poſition 25 Degrees from the North Weſtwards; wherefore this Arch makes an Angle with the Track of the Shade of 77° ¾, and hence the neareſt Diſtance of the Parallels becomes 163 ſuch Miles, which by the other Way was found 164.

If then we conclude the *Axis* of the Shadow, when the Sun was juſt 40 Degrees high, to have extended over 2°. 50′ of a great Circle, we may ſecurely determine the Difference of the Sun and Moon's Diameters at this Time. For the Difference of the Horizontal Parallaxes of the Sun and Moon being found to be 60′. 38″. (as ſhall be hereafter ſhewn, but is not required with extreme Exactneſs for this Purpoſe) the Difference of the Parallaxes in Altitude at both Ends of the Axis, will be found to be 1′. 56″, and by ſo much did the Diameter of the Moon, when forty Degrees high, exceed that of the Sun: Hence the Horizontal Diameter of the Moon, in this Anomaly is found 33′. 27″, which may ſerve for a Rule in all other Caſes.

I forbear to mention the *Chill* and *Damp*, with which the Darkneſs of this Eclipſe was attended, of which moſt Spectators were ſenſible, and equally Judges; or the Concern that appear'd in all Sorts of Animals, *Birds*, *Beaſts* and *Fiſhes* upon the Extinction of the Sun, ſince ourſelves could not behold it without ſome Senſe of Horror.

Laſtly, I have added the following *Synopſis* of ſuch Obſervations as have hitherto come to my Hands.

Place.	Obſervers.	Beginn.	Immerſ.	Emerſ.	Tot.	End.
		h. ′ ″	h. ′ ″	h. ′ ″	′ ″	h. ′ ″
Barton	M. *Bridges*				3. 53	
Bell-bar	M. *Jones*	8. 6. 25	9. 9. 45	9. 13. 27	3. 42	
Broadway *Carmarth.*			8. 47. 00	8. 49. 30	2. 30	10. 21. 57
Cambridge	M. *Cotes*			9. 14. 37		10. 24. 30
Canterbury	M. *Gray*	8. 10. 00				
Cheſter	M. *Ward*	7. 57. 40				10. 6. 35
Crew	M. *Wright*		9. 2. 8		2. 00	10. 9. 00
Dublin	L. *Archbiſh.*	7. 42. 11				9. 49. 40
Dublin	M. *Hawkins*	7. 41. 30				9. 48. 45
Exon	L. *Biſhop*		8. 55. 0	8. 59. 0	4. 00	10. 0. 00
Exon	M. *Hudſon*	7. 47. 30			3. 30	10. 0. 30
Greenwich	M. *Flamſteed*				3. 11	
King's Wald.	M. *Whitſide*				3. 52	
Llanidan *Angleſey*	M. *Rowland*	7. 52. 30				
London	*R. Society*	8. 6. 00	9. 9. 3	9. 12. 26	3. 23	10. 20. 00
Northampt.	M. *Hawkins*		9. 5. 22	9. 9. 24	4. 2	10. 15. 35
Norton-court	D. *Harris*	8. 8. 55	9. 13. 23	9. 14. 22	0. 59	10. 24. 47
Oxon	D. *Keill*				3. 30	10. 15. 10
Paris	*R. Academy*	8. 11. 00				10. 28. 00
Plymouth	M. *Heines*	7. 41. 00	8. 45. 30	8. 50. 00	4. 30	9. 54. 30
Portcheſter	C. *Chandler*		9. 2. 25	9. 6. 15	3. 50	
Salop	D. *Hollings*	7. 58. 00			1. 40	10. 6. 00
Upminſter	M. *Derham*	8. 7. 41	9. 10. 58	9. 14. 6	3. 8	10. 21. 45
Wanſted	M. *Pound*	8. 6. 37	9. 9. 28	9. 12. 48	3. 20	10. 20. 32
Weymouth	M. *Hobbs*		8. 53. 00	8. 58. 00	4. 00	
Witley	M. *Baxter*	7. 59. 0			3. 15	10. 13. 00

Accounts of the ſame *from* abroad, n. 345. p. 314.

2. Since the Publication of the former Account of what was obſerved in *England*, and particularly at *London*, of this Eclipſe, we have received from Foreign Parts the following Obſervations.

— near the Iſland Forte ventura, *by Mr.* J. Edens.

Mr. *J. Edens*, being on his Voyage to the Pike of *Teneriff*, obſerved the Eclipſe at Sea, in Latitude by Obſervation 34°, 20′, and Longitude 0h 54′, Weſt from *London*, as he concluded by their Diſtance and Poſition from the Iſland *Forte Ventura*, which they ſoon after fell in with. He writes, that it began at VIh. 49′, and ended at VIIIh. 47′. this latter very exactly, though not quite ſo nice as to the Beginning.

Had this Gentleman ſignified, what Difference of Meridians there was found between the Place of Obſervation, and the Weſt End of *Forte-Ventura*, we might, without ſenſible Error, have concluded the true Longitude, not only of that Iſland, but alſo of the Pike of *Teneriff*, where *our Geographers* and the *Dutch* have fixed their firſt Meridian. He adds, that the greateſt Darkneſs was about ¾ of the Sun's Diameter, or nine Digits on the North Side.

From *Germany* we have received the following Accounts.

At *Nurenburg*, The Beginning and greateſt Obſcurity could not be ſeen for Clouds, but the End happen'd at xi^h. 10′. ½.

— *at* Nurenburgh.

At *Hamburg*, The Beginning was obſerved at viii^h 57′. the greateſt Obſcurity at x^h. 5′. 30″. when xi ½ *Digg*. were darkned. The End could not be obſerved for Clouds.

— *at* Hamburgh.

At *Keil* in *Holſtein*, The Beginning ix^h. 14′. The greateſt Obſcurity x^h. 19′. 20″, and the Quantity then eclipſed xi *Digg*. 20′. The End was at xi^h. 29′.

— *at* Kiel *in* Holſtein.

At *Berlin*, The Beginning could not be obſerved for Clouds, but the greateſt Obſcurity was at 22 *min*. paſt Ten, when xi *Digg*. were eclipſed. The juſt End was at xi^h. 34′.

— *at* Berlin.

At *Frankfort* on the *Meine*, The Eclipſe began at viii^h. 50′. The greateſt Darkneſs at x^h. 11′, *but perhaps ſhould be* x^h. 01 *min*. the Digits being x. and 34 *min*. The End was obſerved at 10 *min*. paſt Eleven.

— *at* Franckfort *on the* Meine.

By whom theſe Obſervations were made, and with what Inſtruments, we are not as yet informed, but hope they may be exact enough to confirm the *Longitudes* of thoſe ſeveral Places, which are at preſent reaſonably well known.

In a Book entituled, *Nouvelles Literaires*, publiſhed at the *Hague*, *pag*. 404, 405, there is an Account of the Obſervation of this Eclipſe at *Upſal* in *Sweden*, made by M. *Jo. Waller*, Profeſſor of Mathematicks in that Univerſity, who was very careful to obſerve it exactly; the Times being verified by three Clocks perfectly agreeing with one another and with the Sun: But more eſpecially by a Quadrant of five Foot Radius for taking the Sun's Altitude. By this Inſtrument he determined the Height of the Pole at *Upſal* 59°. 51′. 54″. And by the ſame, a little before the Beginning of the Eclipſe, he found the Height of the Sun 39°. 36′. 42″. his Clocks then ſhewing the Hour ix^h. 47′. 50″, which proves that they were very near the true Time. At x^h. 58′. 15″. the Altitude of the Sun being 44°. 17′. 29″, was the Beginning of the total Darkneſs, and at xi^h. 2′. 24″. was the End thereof, *alto ſole* 44°. 29′. 13″. ſo that here the Duration of the total Eclipſe was 4′. 9″, and the Middle thereof but one Third of a Minute after Eleven. And laſtly, the End is ſaid to have happen'd about 4 Minutes before Noon, the Sun being 45°. 42′. 6″. high: But in this is a manifeſt Error, for it makes the Time of Emerſion, or from the Middle to the End, but 55′. 20″; whereas being ſo near the Meridian, 'tis certain that this Emerſion was the greater Part of the Duration of the whole

— *at* Upſal *in Sweden. by Mr.* J. Waller.

whole Eclipſe, and conſequently more than an Hour. Perhaps the Times might be deduced from the Altitudes only, and then the Miſtake might be in ſuppoſing the End ſo much before Noon, as it was really after it. However, to prevent all Doubts, we have compared this Obſervation with what we obſerved of this Eclipſe at *London*, and find, that in the Latitude of $59°. 50'$, the Place where the Middle of total Darkneſs was at $xi^h. 0'. 20''$, was near 19 Degrees more Eaſterly than *London*, (that is exactly in the Meridian of *Dantzick*) and that the Eclipſe began there at $xi^h. 52'\frac{1}{2}$, and ended at $xii^h. 10''$, wherefore the Duration could not be $2^h. 7'. 50''$, as the *Editor* of the ſaid *Nouvelles* has publiſhed; not conſidering, that the Beginning could not be ſeen for Clouds, as in the very next Words he aſſures us.

As to the Darkneſs, it was ſuch, that they could ſcarce diſtinguiſh one another; and beſides *Jupiter*, *Mercury* and *Venus*, of the fix'd Stars, *Caſſiopea*, *Capella*, *Oculus Tauri* and *Orion* (Sirius *not being yet riſen*) were viſible.

Eclipſe of the Sun, Feb. 19, 1718. O. S. *at* Norimberg, *by Mr.* Wurtzelbau, *and at* Berlin, *by Mr.* G. Kirch, n. 357. p. 822.

XVI. From the *Literary News* of *Berlin* we have obtain'd two Obſervations of a ſmall Solar Eclipſe, *Feb.* 19, *St. Vet.* 1718. One at *Norimberg*, by Mr. *Wirtzelbau*; the other obſerved at *Berlin* by Mr. *Kirch*.

At *Norimberg* the Sun roſe ſomething deficient in his upper Limb, which Defect increaſed to 3 full Digits. The Eclipſe ended at $8^h. 8'. 48''$, about 60 Degrees from the Vertex of the Sun to the left Hand. But at *Berlin* the Sun began to be eclipſed preſently after his Riſing, or at $6^h. 49'$ or $49'\frac{1}{2}$. About the Middle of the Eclipſe, or at $7^h. 35'$, the lucid Parts remaining in the Sun were $24'. 40''$. Whence the Digits obſcured were $2^d. 50'$. The End happen'd at $8^h. 28'. 10''$.

Eclipſe of the Moon at Cambridge *in* New-England, *Feb.* 11, 1700, *by Mr.* T. Brattle, n. 202. p. 1633.

XVII. On *Feb.* 11, the Moon roſe eclipſed, and the Horizon was ſo overcaſt, that I deſpaired of having any Obſervations; but at ½ an Hour paſt 6. ſhe came from under the Cloud, and at $6^h. 25'$. I had juſt a Sight of her, and judged her eclipſed about 5 Digits; at

h.	′	
6	29	The Section equidiſtant from *M. Ætna* and *Horminius*.
	32	*Palus Maræotis* begins to be ſeen.
	34½	*Palus Maræotis* and *Mons Apollonius* ½ out.
	37½	*Palus Maræotis* quite free, and *Palus Maræotis* and *Palus Mæotis* in the Perpendicular.
	42½	The Shadow near an Inch from *Palus Maræotis*, *Mons Horminius*, and *Mons Hercules*.
	46½	*Palus Maræotis* in the *Nadir*, and that Part of *Palus Mæotis* to my Right-hand in the Prime Vertical.
	57	The upper Part of the Section is now, and has been for a long Time, in *Inſula Major in Mare Caſpio*, (and the Section now perpendicular,) and the lower Part wheeling about from *Palus Maræotis*.

h ′
7 20 *Mount Sinai* firſt appears at 22′ wholly free.
25½ *Palus Maræotis* and *Mons Horminius* near perpendicular.
43 The Eclipſe over in the Teleſcope, and at 49 to the naked Eye.

My Clock was ſet by my Ring-Dial about Nine of the Clock in the Morning, as exactly as I could judge; and the Obſervation was made with my 4½ Foot Teleſcope, with all four Glaſſes in it.

XVIII. 1.]

Eclipſe of the Moon, Dec. 12. 1703. *at* Cambridge *in* New England, *by Mr.* T. Brattle, n.292.p.1656.

Time by the Clock.
h ′
11 45 In the Morning, that Part of the Moon's Diſk near *Alabaſtrinus*, look'd ſomewhat duskiſh, and the Eclipſe beginning to enter between *Palus Meræotis* and *M. Porphyritis*.
11 53 The true Shadow was well entred.
58 *M. Porphyritis* juſt cover'd.
12 03½ Near 3 Digits darkened.
7½ *Mount Ætna* begins.
9½ Quite cover'd.
14½ *Lacus Niger Major* and *M. Sinai* almoſt equidiſtant from the Section of the Shadow, *Lacus Niger Major* being ſomewhat the nearer of the two.
18½ *Lacus Niger Major* begins 19½ quite cover'd.
21¾ *Mount Sinai* begins.
21¾ Quite cover'd, and the Moon about 6 Digits eclipſed.
12 24½ *Besbicus* begins.
26 Quite cover'd.
28¾ *Byſantium* begins.
29½ Cover'd, and *Mount Horminius* begins.
32 *Apollonia* begins.
33 Cover'd.
37 The Shadow equidiſtant from *M. Corax* and *Mount Paropamiſus*, or ſomewhat nearer to *M. Corax*.
39½ Between 9 and 10 Digits eclipſed.
43 *M. Corax* begins.
12 44¾ *Palus Mæotis* begins, and at 45¾ the Inner of *M. Paropamiſus* begins.
50 *Palus Mæotis* quite cover'd.
51½ The Moon not quite eclipſed.
52 Nor yet.
53 Nor yet.
54 Scarce.
54½ Quite immerged and the Mora begins.
14 39 Preciſely, ſhe emerged between *Palus Maræotis* and *Mons Porphyritis*.

h	′	
	42	*Palus Mareotis* begins.
	43	Quite clear.
	47	*M. Porphyritis* quite clear.
	55	About 3 Digits reſtored.
	59	Mount *Ætna* begins.
15	02	That and *Lacus Niger Major* at the ſame Time clear.
	8½	*Mount Sinai* about half free.
	9½	Quite free, and about 6 Digits reſtored.
	15	*Besbicus* free.
	19¼	*Byſantium* free.
	29½	About 9 Digits ſeem'd to be reſtored.
	30¾	*Mons Herculis* free.
	32¾	*Palus Mæotis* begins.
	38½	Quite free.
	41½	*Inſula Major in Mare Caſpio* free, and in the Middle of the Section.
	42½	Not yet wholly clear.
	45	Fully over in the Teleſcope, tho' a Kind of a Smoak remained ſome little after to the naked Eye.

In order to the Adjuſting of the Time, I ſet my Clock with the greateſt Exactneſs I could the Morning preceding, both from my Ring-Dial and the Riſing of the Sun, which I very narrowly watch'd and obſerved, and found it to agree with the Sun's ſetting the following Evening; ſo that it went all the Time the Eclipſe was, very ſteadily and regularly; but for the greater Certainty and Satisfaction, I took the Altitudes of the following Stars with the Braſs Quadrant with Teleſcope Sights out of my Chamber Window, the Lowneſs whereof would not permit me to take them, when they were at all higher elevated.

*. in dextro humero Orionis.

By the Watch.			Comp. Alt.				Differ.			
	h	′			h	′	″	′	″	
	6	15	78	18	6	13	40	1	20	*So that my Clock went by theſe Obſervations neareſt 1′ too faſt.*
	6	21½	77	03	6	20	28	1	02	
		26¼	76	11	6	25	08	1	07	
Procyon										
	8	9¼	77	20	8	08	04	1	11	
		14½	76	20	8	13	32	0	58	
		21	75	13	8	19	36	1	24	
Re-	10	8½	77	46	10	07	18	1	12	
gulus		17¼	76	11	10	15	58	1	17	

2.] I had the good Fortune at *London* near the *Exchange* to make ſome few Obſervations of the Eclipſe of the *Moon* of *December* the 11th, 1703. (of which I gave an Account to the Society ſome Time ſince) as follows:

— *the* ſame *obſerv'd at* London, *by* *Mr.* J. Hodgſon, n. 291. p. 1594, n. 292. p. 1637.

The Heavens being cloudy moſt Part of the Night, it was 35′ after Four in the Morning following, before I could perceive that the Moon was eclipſed; and then as near as I could judge, ſhe had been ſo about three or four Minutes at moſt, from whence we may conclude it began at *London* about 31 or 32 Minutes after Four the ſame Morning.

Mr. *Brattle* found, that at 44 Minutes after Eleven at Night, Part of the Moon's Diſk look'd ſomewhat duſkiſh, and that at 52 Minutes, the Shadow was well enter'd, *ſo that from hence, as well as from a Compariſon of the Ingreſs and Egreſs of the principal Spots, it probably began there about 49 Minutes after Eleven, whence it follows, that* Cambridge *in* New-England *lies* $4^h\,42'\,\frac{1}{2}$, *or* 70 37′ *to the Weſtward of the Meridian of* London.

Difference of Longitude *between* London *and* Cambridge *in* New-England.

I happen'd to ſee the Moon the ſame Morning at 35 Minutes after Five, when ſhe wanted at moſt but three Minutes of being totally eclipſed; ſo that at *London* ſhe immerged at 38 Minutes paſt Five.

Mr. *Brattle* ſaw her immerge exactly at 54 Minutes after Twelve, whence it follows, that the Difference of the Meridians found by comparing theſe Obſervations, is $4^h\,43'\,\frac{1}{2}$, or 70° 52′, agreeing very well with the former; ſo that by taking a Mean between them, the Difference of Longitude of the two Places $4^h\,43'$, or 70° 45′.

I ſaw no more of the Eclipſe that Morning, by reaſon of the Clouds, and ſhould be very glad to meet with ſome other Obſervations to confirm theſe; but their mutual Agreement gives great Reaſon to believe that the Deductions are good, and may be rely'd upon; for during the Eclipſe I had a View of the Moon at leaſt twenty Times, tho' Clouds frequently intervening have made this Account of mine leſs accurate and certain than otherwiſe it would have been.

XIX.

Immerſions.	Time corrected by Altitude.		
	h	′	″
A very notable *Penumbra*, (Evening)	6	52	
Palus Maræotis is cover'd	6	58	20
Mons Porphyrites begins	7	8	15
Is cover'd	7	9	20
Mount *Ætna* begins	7	16	
Is quite covered	7	17	15
Mount *Sinai* begins	7	21	40
Quite cover'd	7	22	40
The Iſle of *Corſica* is cover'd	7	24	
The greater *black Lake* is cover'd	7	31	40
The Iſland *Besbicus*	7	33	
Bizantium	7	36	30

Eclipſe of the Moon, Apr. 5. 1707, *at* Boſton *in* New-England, *by* *Mr.* T. Brattle, n. 312. p. 2471.

			h	′	″
Immerſions.					
Mount *Horminius*			7	37	20
Mount of *Apollo*			7	40	30
Mount *Hercules*			7	44	30
Mount *Corax*			7	51	30
Palus Mæotis begins			7	52	45
The great Iſland in the *Caſpian* begins			7	54	45
Is cover'd			7	56	
Palus Mæotis is quite cover'd			7	57	30
The Moon quite immerſed			8	1	15
Emerſions.					
The Complement of the Altitude of *Arcturus*	53°	34′	8	28	
	51	30½	8	39	15
The Complement of the Altitude of the Star that follows the bright Star in the Northern Crown					
Latitude 44° 33′	60°	2′	9	0	30
	56	57	9	17	15
The Moon plainly began to emerge			9	46	30
Mount *Ætna* was wholly illuſtrated			10	9	30
Mount *Sinai* wholly appear'd			10	10	15
The Iſle *Besbicus*			10	25	
Bizantium			10	28	30
The Mount of *Apollo*			10	33	
Mount *Hercules*			10	36	30
Palus Mæotis begins			10	44	
The greater Iſle in the *Caſpian* is reſtor'd			10	47	
Palus Mæotis wholly uncover'd			10	49	
The Moon is fully illuminated			10	54	

Eclipſe of the Moon, April 11, 1707, *at* Zurich, *by the two Doctors* Scheuchzer's, n. 310. p. 2394.

XX.

h	′	″	
12	9 ad 18		The *Penumbra* on the Side of *Maræotis*.
	18	40	The true Shadow within the Disk.
	20	15	*Palus Maræotis* in the Shadow.
	23		The Beginning of *Mare Eoum*.
	25	20	The Mount of *Alabaſter*. The Middle of *Mare Eoum*.
	27	40	The Beginning of the Bay of *Sirbon*.
	29		The Middle of the Bay of *Sirbon*, and *Mare Ægyptiacum*.
	29	20	The Beginning of the Iſland *Cercinna*.
	29	30	The Southern Lake.
	30	30	The Middle of *Cercinna*.
	31	40	The End of *Cercinna*.
	33		The utmoſt Promontory of Mount *Sopher*.
	34		The Iſlands between *Sicily* and *Cercinna*.
	35		The Beginning of *Mauritania*, and of *Sirus Hyperboreus*.
	36	40	The Middle of *Sinus Hyperboreus*.

h	′	″	
	37	20	*Mare Pamphilium.*
	37	30	*Crete.*
	37	40	The Beginning of *Ætna.*
	38	40	The Middle of *Ætna.* *Melos.* *Carpathos.*
	39	30	The End of *Ætna.*
	41		*Rhodes.*
	43	40	The Beginning of *Sinai.*
	45		The Middle of *Mare Adriaticum* and *Sinai.*
	45	20	The End of *Sinai.*
	46	30	The Middle of *Adriaticum.*
	48	40	The Beginning of *Propontis*, and of *Mare Hyperboreum.*
	51	30	The Middle of *Propontis*, and the End of *Adriaticum.*
	52	40	The Beginning of the *Greater Black Lake.*
12	53	10	*Lacus Thraſumenus.*
	53	30	The Middle of the *Greater Black Lake.*
	54	30	The Beginning of the Iſland *Beſbycus.*
	55	10	The Beginning of *Pontus Euxinus* in the Bay *Salmydeſſus.*
	56		The End of *Propontis.*
	57	30	The Beginning of the *Lower Euxine Sea.*
	58		The Beginning of *Byzantium.*
	59	10	——— The End.
	59	40	The *Acheruſian* Promontory.
1	1		The Beginning of *Boryſthenes.* *Apollonia.*
	1	30	The Middle of the *Euxine Sea.*
	3	20	The Middle of the *Athenian* Bay.
	4	40	The Marſh of *Byce.*
	5	40	The Promontory of *Heracleum.*
	7	40	The Middle of *Cochlis.* The End of the farther Bay of *Pontus.*
	8	30	The Middle of the Lake *Coroconda.*
	9	20	The Beginning of the Promontory of *Hercules*, and of the *Caſpian Sea.*
	11	40	The Beginning of *Palus Amadoca.*
	16	20	The Middle.
	18	10	The End.
	20		The bitter Marſhes and the Leſſer Lake.
	20	40	The Greater Lake.
	22	10	A very ſlender lucid Margin.
	23	20	The whole Body of the Moon in the Shadow.
	24	40	The Moon's Disk was almoſt entire, except the *Mediterranean Sea.* It ſhin'd with a Kind of dilute Brightneſs, ſo that the Seas might be diſtinguiſh'd thro' the Tube.
	40		No other Spot but *Palus Mæotis* could be diſtinguiſh'd through the Tube.
	45		The middle Disk of the Moon is obſcured more and more, the Circumference continuing brighter.

h	′	″	
2	12		The Disk of the Moon ſhined to the naked Eye with a reddiſh Colour, nor could any Spot be diſtinguiſhed through the Teleſcope.
	15		The whole Disk grew more and more obſcure, the Circumference remaining a little brightiſh.
	28		The Disk was brighter over againſt *Palus Maræotis*, and there was a very denſe Shadow towards *Palus Mæotis*.
	33		By Degrees the whole Disk became brighter; but a greater Obſcurity cover'd *Palus Mæotis*, and the neighbouring Places.
	51	40	By Degrees the Images of the Seas return.
	56	30	The *Euxine Sea* and the *Caſpian* continue in the Middle of Obſcurity, as it were cover'd by a thick Cloud.
3	5		*Mare Eoum* and the neighbouring Places might be diſtinguiſh'd, tho' the Moon had not yet emerged out of the Shadow.
	9	40	The true Beginning of the Emerſion.
	11	30	*Palus Maræotis* begins to emerge.
	13		It is emerged.
	15	40	*Mare Eoum* begins.
	21	30	*Sinus Sirbonius* and the *Egyptian Sea* emerged.
	26		*Caſſiotis Reggio* comes out, and the Iſle *Circinna* ſome Minutes before.
	27	40	*Mount Athos* and the Iſland *Malta* come out.
	31		*Mauritania* emerges.
	38		——— *Corſica* and *Sicily*.
	44		——— The *Adriatick Sea*.
	45	20	——— The Middle of *Propontis*.
	49		——— *Besbycus*.
	52		——— *Byzantium*.
	57	30	——— Promont. *Acheruſ.*
4	5	20	The *Euxine Sea*, and the Middle of the *Caſpian* came out.
	6		*Palus Mæotis* begins.
	2		The *Caſpian* emerged, and the Middle of *Mæotis*.
	11	20	*Mæotis* emerged.
	13	40	The *Penumbra*.
	14	20	All the Moon entire.

The Shadow ſeem'd to me more diſtinct in the Emerſion than it was in the Immerſion.

12	18	40	The Beginning of the Eclipſe in the true Shadow.
1	23	20	The greateſt Obſcuration.
3	9	40	The Beginning of Emerſion.
1	46	30	The Duration of total Obſcuration.
4	14	20	The End of the Emerſion.
3	55	50	The whole Duration.

h	'	"	
1	5	40	From the Beginning to the total Immerſion of the Moon.
1	5	40	From the Emerſion of the total Eclipſe to the End.

XXI. As I was coming from *London*, *Sept.* 18, in the Evening, I obſerved, for Half an Hour or more, a thin Shade to poſſeſs that Part of the Disk where the Eclipſe began, which remain'd a good While after the Eclipſe was over. After I got Home, I got all Things in Readineſs before the Eclipſe began. The principal Obſervations were as follow:

Eclipſe of the Moon, *Sept.* 18, 1708. *at* Upminſter, *by Mr.* W. Derham, n. 320. p. 312.

The Corr. App. Time.			
h	'	"	
7	56	30	A thin Penumbra.
7	57	40	A darker Penumbra.
7	59	00	Yet darker, which may paſs for the Beginning of the Eclipſe.
8	00	00	The Eclipſe no Doubt begun.
9	01	00	The lucid Parts of the Moon, not long before the Middle of the Eclipſe, were 925 Parts of my Micrometer.
9	16	40	Diameter of the Moon 1634 Parts of the Micrometer.
10	23	11	The End of the Eclipe draws nigh.
10	25	00	A little Obſcuration.
10	26	00	Leſs.
10	28	15	A very little, excepting the Duskiſhneſs before mentioned.

XXII. In the laſt *Lunar* Eclipſe on *Feb.* 2, 1709-10, the Time of the End, (which was what alone the Want of a proper *Apparatus*, and a favourable Sky would give me Leave exactly to determine) I found to be the ſame (with but a very inconſiderable Difference) which the *Calculation*, according to Sir *Iſaac Newton*'s admirable Theory, promiſed me to expect.

The Account of the Moon's *Eclipſe*, Feb. 2, 1709-10. Compared *with the* Calculation, *by Mr.* H. Creſſener, n. 325. p. 16.

I have added the Calculation from Mr. *Flamſtead*'s Tables according to Mr. *Horrox*'s Theory, as I find them publiſh'd in Mr. *Whiſton*'s Aſtronomical Lectures, with the *Radix's* or the mean Motions, corrected according to their firſt Author's later Obſervations, which are the ſame with thoſe aſſumed in Sir *Iſaac Newton*'s Theory.

By comparing theſe two Calculations, we may obſerve, that tho' moſt of the additional Equations in Sir *Iſaac Newton*'s Theory be very ſmall in this Situation of the Moon, yet they all conſpire ſo as to make its Place conſiderably more agreeable to Obſervation, than thoſe of *Horrox*'s Syſtem.

The Obſervation was made at *Streatham*, about ſix Miles near direct South of *London*, with a very good eight Foot Teleſcope. To correct the Clock, (for Want of an Inſtrument) I carried with me next Day two Watches, that were before adjuſted to the Clock, and compared them with Mr. *Flamſtead*'s at the Royal Obſervatory, having firſt noted its Error by an Obſervation of the Sun's Tranſit of the Meridian his Aſſiſtant communicated to me. Upon my Return I found my Watches ſtill to agree together, and to my Clock, which proved them to have gone true, and gave me the exact Error of my Clock, and the true Time at Obſervation.

Mr. *Flamſtead* has ſince been pleaſed to acquaint me, that by his Obſervation of the meridional Tranſit of the *Lyon's Heart* during the Eclipſe, his Clock needed a yet farther Correction of one Minute, which I have here accounted for.

$17\frac{09}{10}$ *Feb.*	*D.*	*H.*	*M.*	*Sec.*
The mean Time of the mean Oppoſition	2	4	9	42
The mean Time of the true Oppoſition	2	10	54	48
At which the true Place of the Sun is	10	24	55	50
And its Æquation to be added.				

The Place of the Moon from Sir Iſaac New*ton's Theory.*

	S.	*D.*	′	″
Mean Motion of the Moon	4	26	57	37
Annual Æquation Subtr.			8	34
The correct mean Motion	4	26	49	03
Mean Motion of Apog.	11	18	13	54
Annual Æquation of Apog. Ad.			14	31
Correct mean Motion of Apog.	11	18	28	25
Second Æq. from the Diſt. of Ap. from Sun Ad.			2	57
Place of the Moon the 2^d Time Æquat.	4	26	52	00
Mean Motion of Node	11	01	34	25
Æquation of Node Subt.			06	54
Correct mean Motion of Node	11	01	27	31
The 3^d Æquation of the Moon from Node's Aſpect with the Sun Subt.				10
Place of the Moon the 3^d Time Æquated	4	26	51	50
Second Æquation of Apog. Subtr.		7	45	41
True Place of Apog.	11	10	42	44
Mean Anomaly	05	16	09	06
Æquation of Center Sub.		1	53	31
Moon's Place the 4th Time æquated	4	24	58	19
The Variation. Ad.				11
Moon's Place the 5th Time æquated	4	24	58	30
The 6th Æquation from the Diſtance of Luminaries and Apog. Ad			1	20
Moon's Place 6th Time æquated	4	24	59	50
The 7th Æquation. Ad.				34
True Place of the Moon in its Orbit	4	25	00	24
True Place of the Sun	10	24	55	50
Moon beyond the Oppoſition			4	34
Which divided by the Horary Motion of Moon from Sun, gives			7	42
	D.	*H.*		
The mean Time therefore of Oppoſit. *Feb.*	2	10	47	06
And the true Time	2	10	32	20

Mean

Mean Motion of the Moon	4	26	57	37
Phyſical Parts Sub.			8	21
Correct mean Motion	4	26	49	16
Mean Motion of Apog.	11	18	13	54
Æquation of Apog. Sub.		7	25	00
Mean Anomaly	5	16	00	22
Æquation of the Center Sub.		1	53	53
Place of Moon in its Orbit	4	24	55	23
Diſtance from the Oppoſition				27
That is in Time to be added				45½
The mean Time therefore of true Oppoſition is exactly	*D.*	*H.*		
	2	10	55	33
The apparent Time	2	10	40	41
Place of Moon in Ecliptick	4	24	57	27
Reduction between the true Oppoſition and Middle of Eclipſe. Ad.			2	47
	D.	*H.*		
Middle of Eclipſe	2	10	43	34
Continuance of Eclipſe		2	55	06
Digits eclipſed		9	55	
Beginning of Eclipſe	2	9	16	01
End of Eclipſe		12	11	07
End of Eclipſe by the Moon's Place from Sir *Iſaac Newton*'s Theory		12	02	00
End by Obſervation		12	01	30
End by Calculation from *Horrox*'s Theory		12	11	08

The Place of the Moon according to Mr. Horrox's *Theory.*

The Error therefore of Sir *Iſaac Newton*'s Thereory is by this Obſervation but half a Minute, or none; of *Horrox*'s Syſtem, nine Minutes and a Half.

Eclipſe of the Moon, Jan. 12. 1711-12, *at* Upminſter, *by Mr.* W. Derham, n. 336. p. 522.

XXIII. The Evening being clear, gave me a good Opportunity of obſerving the Lunar Eclipſe. The Times are very nice, and the Obſervations made with an excellent Six-foot Teleſcope, as followeth.

h	′	
6	15	A Duskiſhneſs upon the N. Eaſt-ſide of the Moon.
6	36	A thick *Penumbra* on the Moon.
6	37	The *Penumbra* ſo denſe, that it may be taken for the Beginning of the Eclipſe.
6	39	The Eclipſe undoubtedly is begun.
6	41	The Shadow ſo dark, that it nearly hid the Moon's N. Eaſterly Limb.

h.	′	
7	21	Moon's Diameter by the Micrometer 1612 equal Parts, equal to 31′ 25″.
7	25	The Diſtance of the Shadow from the oppoſite luminous Limb of the Moon, repreſented by the Line *l. u.* was 1025 Parts of the Micrometer, equal to 20 Minutes.
8	31	End of the Eclipſe is very near.
8	32	End of the Eclipſe.
8	32	45″ Eclipſe is undoubtedly ended.
8	36	A *Penumbra* is left.

It unluckily fell out, that I diſordered my Micrometer at the Beginning of the Eclipſe; ſo that I could not take with any Exactneſs the Inclination of the Cuſps, and ſome other Matters I had a Mind to have obſerved; to ſupply which Defect in ſome Meaſure, I have ſent a *Type* of the Eclipſe, as well as I could, by Gueſs. And from the ſame Defect I cannot warrant the Micrometrical Meaſures of the Moon's Diameter, and her eclipſed Parts to be otherwiſe, than ſomewhat near the Truth; perhaps not exactly true.

Fig. 120. A *Type* of the *Lunar Eclipſe*, Jan. 12, 1711-12.

m. i. x. r. repreſents the two Claſpers of the Micrometer, parallel to the Equator.

N. The Northern, *S.* the Southern Part of the Moon's Disk, running between the Claſpers of the Micrometer.

l. u. The enlightened Part of the Moon, being 1025 Micrometrical Parts, or 20′.

I am ſorry I had not *Hevelius*'s Map of the Moon, to have noted the Spots the Shadow paſſed over.

XXIV. Eclipſe *of the Moon*, Oct. 30, 1715, *at* Wanſted, *by Mr.* J. Pound.

Obſ.	App. Time. h	′	″		′	″
1	15	09	00	The Eclipſe had been for ſome Time begun		
2		17	00	The Moon's Diameter meaſured by a Micrometer was	34	04
3		22	25	The Chord connecting the Horns	30	28
4		35	45	The enlightened Part of the Diameter continued to the Chord between the Horns	19	58
5		43	24	The enlightened Part of the Diameter	13	52
6		49	50	The ſame repeated	12	02
7		52	43	The ſame repeated	11	44
8		56	51	The enlightened Part of the Diameter continued to the Chord between the Horns	15	22
9		59	27	The enlightened Part of the Diameter	10	35
10	16	04	04	The ſame repeated	9	43

	h	'	''		'	''
11		18	34	The ſame again repeated	09	07
12		23	45	The Chord between the Horns	32	35
13		26	30	The ſame repeated	33	07
14	16	31	16	The ſame again At which Time alſo the Shade paſſed thro' the Middle of *Schikardus*	33	19
15		37	15	The Chord between the Horns, agreeing with the ☽'s Diameter	33	57
16		40	45	The inlightned Part of the Diameter	11	56
17		43	40	The ſame produced to the Chord between the Horns	16	13
18		46	55	The ſame repeated	17	28
19		47	57	The inlightned Part of the Diameter	13	38
20		52	57	The ſame	15	30
21		55	27	The Edge of the Shadow paſſed through the Middle of *Gaſſendus*.		
22		56	12	The inlightned Part produced to the Chord between the Horns	19	58
23	17	02	45	The Chord between the Horns	32	12
24		8	20	The ſame repeated	30	28
25		10	39		29	56
26		13	00		28	31
27		15	29	The ſame again —— ——	27	33
28		17	37		26	35
29		19	35		25	36
30		21	47	The ſame again —— ——	24	38
31		23	24		23	39
32		24	54		22	40
33		26	27	The ſame again —— —— ——	21	41
34		27	57		20	42
35		29	08		19	43
36		30	20	The ſame again —— —— ——	18	44
37		31	07		17	45
38		32	04		16	46
39		32	50	The ſame again —— ——	15	47
40		34	12		13	48
41	17	35	20	The ſame again repeated	11	42

At 17^h. $39'$. the Eclipſe was thought to be ended; and was viſibly ſo at 17^h. $41'$: But by comparing the laſt Obſervations of the Chords between the Horns, it follows, that the true End of the Eclipſe was at 17^h. $38'$. $20''$. At 17^h. $43'$. the Moon's Diameter was $33'$ $40''$.

The middle cannot be ſuppoſed to be very accurately determined by theſe Obſervations, which are not ſufficiently diſtant from the Time of the greateſt Obſcuration. However by comparing ſeveral of them together, the Middle will be obtained, *viz.*

	h	′	″
By Obſ. 3. compared with Obſ. 24. at	16	15	21
By Obſ. 4. compared with Obſ. 22. at	16	15	58
By Obſ. 5. compared with 19. and 20. at	16	16	00
By Obſ. 6. and 7. compared with 16. at	16	15	48

By reaſon of Clouds I could not ſee the Beginning of the Eclipſe, nor make ſuch Obſervations of the Moon's immerging into the Shadow, as I did of her emerging out of it.

By Obſervation 11. compared with Obſervation 15. the Digits eclipſed were 8¼.

The Angles were meaſured by a *Micrometer* in a 15 Foot Teleſcope: I have not conſidered how far they are conſiſtent with one another; they being ſet down here exactly, as they were firſt taken.

This Eclipſe is the more conſiderable, as happening very near the Moon's *Perigee*, and therefore uſeful to verify her *Anomaly*; as alſo to limit the greateſt Diameter of the Shadow of the Earth, and conſequently the Parallax of the Moon. This may very properly be compared with that of the 19*th* of *October*, 1697, whoſe middle was at 7ʰ. 41′. P. M. at *London*, and Quantity the ſame as now.

The Times by the Clock were 17′. 45″. ſooner than the apparent Time, as were found by the following Obſervations of *Cor Leonis* and *Arcturus*, which through the Clouds were but juſt diſcernible.

Apparent Zenith Diſtance		Time by the Clock			Apparent Time by Calculat.			The Difference			
of Cor ♌											
										Mean Diff.	
°	′	h	′	″	h	′	″	′	″	′	″
70	16½	13	32	43	13	50	35	17	52		
69	38		36	50		54	44	17	54		
69	09		40	06		57	51	17	45	17	50
68	40		43	09	14	00	59	17	50		
68	08		46	37		04	26	17	59		
of *Arctur.*											
65	19	17	37	40	17	55	24	17	44		
65	06		39	12		56	48	17	36		
64	41		41	49		59	29	17	40	17	40
63	47		47	40	18	05	17	17	37		
								Clock too ſlow		17	45

The Latitude of *Wanſted* is 51°. 34′. Its Longitude is 8″ in Time Eaſtward from the *Obſervatory* at *Greenwich*.

N. B. *The Account given of this Eclipſe by the Reverend Mr.* William Derham, *who obſerv'd it at* Upminſter, *is agreeable to this, as far as Clouds would permit him to obſerve.*

XXV.

Obſervations *on the* Heavens *at* Greenwich, 1711, 1712, *by Mr.* J. Flamſtead, n. 337. p. 65.

— *of* Saturn.

Obſervations of SATURN. 1711. 1712.

Time by the Clock.	Time corrected.	*Friday, Jan.* 5, 1711.	Diſtance from the Zenith.
10 14 26	10 14 41	The Heel of *Caſtor* μ ♊ paſs'd over	28 50 10
11 11 38	11 11 53	In the Groin of *Pollux* the Star δ paſs'd over ———	28 59 00
12 4 45	12 5 00	*Saturn* paſs'd over ———	30 23 20
		Saturn's Right Aſcenſion 119.01.00	
		Diſtance from the North Pole 68.55.20	
		Sunday, Jan. 7.	
11 2 53	11 0 31	δ in *Gemini* paſs'd over —	28 59 20
11 50 36	11 48 14	μ in the Northern Foot of ♋ paſs'd over	29 5 20
11 55 22	11 53 00	*Saturn* paſs'd over ———	30 21 50
12 15 41	12 13 19	* in *Cancer* (according to *Bayer*) paſs'd over ———	30 4 30
12 26 18	12 23 56	γ in *Cancer*, the Northern Aſs paſs'd over	28 59 50
		Saturn's Right Aſcenſion 118.52.00	
		Diſtance from the North Pole 68.53.50	
		Monday, Jan. 8.	
10 58 35	10 57 49	δ in *Gemini* paſs'd over ———	28 59 15
11 50 46	11 50 00	*Saturn* paſs'd over ———	30 20 35
12 11 25	12 10 30	* in *Cancer* paſs'd over ———	30 4 25
		Saturn's Right Aſcenſion 118.46.30	
		Diſtance from the North Pole 68.52.35	
		Thurſday, Jan. 25.	
9 45 53	9 46 26	δ in *Gemini* paſs'd over ———	28 59 10
10 32 27	10 33 00	*Saturn* paſs'd over ———	30 4 00
11 10 54	11 11 27	δ in *Cancer*, the Southern Aſs paſs'd over	32 17 50
		Saturn's Right Aſcenſion 117.23.00	
		Diſtance from the North Pole 68.36.00	

Time by the Clock.	Time corrected.	*Saturday, Jan.* 25, 1711.	Diſtance from the Zenith.
9 37 25	9 38 2	δ in *Gemini* paſs'd over ——	28 59 20
10 13 11	10 13 48	*l* under the Side of *Pollux* paſs'd over	30 51 50
10 23 23	10 24 00	*Saturn* paſs'd over ——	30 2 30
10 40 59	10 41 36	*d* behind the Tail of ♋ paſs'd over	32 14 10
10 50 16	10 50 53	η in *Cancer* paſs'd over ——	30 4 35
		Saturn's Right Aſcenſion 117.14.00	
		Diſtance from the North Pole 68.34.30	
		Thurſday, Jan. 30.	
9 29 45	9 26 55	δ in *Gemini* paſs'd over ——	28 59 40
10 14 50	10 12 00	*Saturn* paſs'd over —— ——	30 0 00
10 33 20	10 30 30	*d* in *Cancer* paſs'd over ——	32 14 10
10 42 35	10 39 45	η in *Cancer* paſs'd over —— ——	30 4 45
		Saturn's Right Aſcenſion 117.00.30	
		Diſtance from the North Pole 68.32.00	
		Wedneſday, Feb. 28.	
8 18 32	8 15 00	*Saturn* paſs'd over ——	29 43 00
8 27 11	8 23 39	μ paſs'd over in the Northern Foot of the *Crab* —— ——	29 5 40
9 2 50	8 59 18	The *Northern Aſs*, γ of the *Crab*, paſs'd over —— ——	29 0 20
10 39 59	10 36 27	γ the bright Star of the *Lion's Neck* paſs'd over —— ——	30 12 05
		Saturn's Right Aſcenſion 115.31.30	
		Diſtance from the North Pole 68.15.00	
		Tueſday, March 1.	
8 14 5	8 11 00	*Saturn* paſs'd over —— ——	29 42 50
8 22 47	8 19 42	μ in *Cancer* paſs'd over —— ——	29 5 35
8 58 28	8 55 23	The *Northern Aſs* paſs'd over ——	29 0 15
10 35 36	10 32 31	The bright Star of the *Lion's Neck* paſs'd over —— ——	30 12 00
		Saturn's Right Aſcenſion 115.30.30	
		Diſtance from the North Pole 68.14.50	
		Friday, Nov. 9.	
17 21 12	17 21 23	The Star following ϖ in the *Crab* paſs'd over —— ——	35 21 10
17 29 49	17 30 00	*Saturn* paſs'd over —— ——	34 9 50
18 13 25	18 13 36	The South Star η in the *Lion's Neck* paſs'd over —— ——	33 18 50
		Saturn's Right Aſcenſion 136.58.00	
		Diſtance from the North Pole 72.42.00	

Monday,

Time by the Clock.	Time corrected.	*Monday, Nov.* 19, 1711.	Diſtance from the Zenith.
16 46 20	16 41 00	*Saturn* paſs'd over ——— —	34 8 00
16 59 31	16 54 11	A Teleſcopic Star *a* paſs'd over —	33 45 30
17 29 59	17 24 33	The South Star *η* in the *Lion's Neck* paſs'd over ———	33 18 30
		Saturn's Right Aſcenſion 136.58.30	
		Diſtance from the North Pole 72.40.05	
		Thurſday, Nov. 22.	
16 24 36	16 19 30	The Star following *π* in *Cancer* paſs'd over ——— ———	35 21 30
33 06	16 28 00	*Saturn* paſs'd over ———	34 6 50
46 27	16 41 21	The aforeſaid Teleſcopic Star paſs'd over	33 45 10
17 16 51	17 11 45	The South Star in the *Lion's Neck* paſs'd over ——— ———	33 18 30
		Saturn's Right Aſcenſion 136.55.45	
		Diſtance from the North Pole 72.39.00	
		Sunday, Dec. 30.	
11 9 43	10 52 42	*γ* in the Right Foot of *Gemini* paſs'd over ——— ———	34 51 30
13 29 25	13 12 24	The Star before *o* in *Cancer* paſs'd over	35 4 00
13 49 01	13 32 00	*Saturn* paſs'd over ——— —	33 30 00
14 39 50	14 22 49	The bright Star in the *Lion's Neck* paſs'd over ——— ———	33 18 40
		Saturn's Right Aſcenſion 134.10.00	
		Diſtance from the North Pole 72. 2. 5	
		Saturday, Jan. 12, 1712.	
11 39 52	11 33 06	*ζ* at the Tail of *Cancer* paſs'd over —	32 59 10
12 40 46	12 34 00	*Saturn* paſs'd over ———	33 12 00
12 43 16	12 36 30	The Star following *π* in *Cancer* paſs'd over ——— —	35 22 20
13 36 44	13 29 58	The *Lion's Heart* paſs'd over —	38 6 55
		Saturn's Right Aſcenſion 134.12.00	
		Diſtance from the North Pole 71.44.00	
		Saturday, Jan. 19.	
11 45 31	11 36 55	The *Southern Aſs* paſs'd over — —	32 17 10
11 58 14	49 38	The Southern Star at *o* in *Cancer* paſs'd over ——— —	35 3 50
12 11 36	12 3 00	*Saturn* paſs'd over — —	33 2 5
12 20 00	11 24	The Teleſcopical Star *b* paſs'd over —	32 33 20
		Saturn's Right Aſcenſion 133.37.00	
		Diſtance from the North Pole 71.34.10	

Time by the Clock.	Time corrected.	*Sunday, Jan.* 27, 1712.	Diſtance from the Zenith.
10 57 50	11 4 31	The Southern Aſs paſs'd over ——	32 17 10
11 10 54	11 17 35	The Northern Star at *o* of *Cancer* paſs'd over ——	34 48 10
11 21 19	12 28 00	*Saturn* paſs'd over ——	32 50 20
11 32 20	39 01	The Teleſcope Star *k* paſs'd over ——	32 33 25
		Saturn's Right Aſcenſion 132.58.00	
		Diſtance from the North Pole 71.22.20	
		Monday, March 31.	
7 8 46	7 7 41	The Southern Aſs paſs'd over ——	32 16 50
7 20 35	7 19 30	*Saturn* paſs'd over ——	32 03 30
7 36 50	7 35 45	The preceding Star at *π* in *Cancer* paſs'd over ——	35 19 10
7 39 36	7 38 31	The Subſequent at *π* paſs'd over ——	35 21 20
8 31 51	8 30 46	The Southern Star in the *Lion's Neck* paſs'd over ——	33 18 40
		Saturn's Right Aſcenſion 130.02.00	
		Diſtance from the North Pole 70.35.30	
		Friday, Nov. 7.	
18 17 13	18 22 00	*Saturn* paſs'd over ——	37 57 30
18 26 13	18 31 00	Star in the *Lion* mark'd 40 in *Britiſh Catal.* paſs'd over ——	41 14 10
18 28 35	18 33 22	Star mark'd 41 in the ſame, paſs'd over	40 15 20
		Saturn's Right Aſcenſion 150.15.30	
		Diſtance from the North Pole 76.29.40	
		Monday, Nov. 17.	
17 33 19	17 34 59	The *Lion's Heart* paſs'd over ——	38 7 20
17 42 20	17 44 00	*Saturn* paſs'd over ——	38 00 50
17 57 48	17 59 28	*ρ* near the *Lion's Breaſt* paſs'd over	40 41 45
18 14 19	18 15 59	*l* in the *Lion's Belly* paſs'd over ——	39 24 50
		Saturn's Right Aſcenſion 150.31.00	
		Diſtance from the North Pole 76.33.00	

—*Of* Jupiter.

Obſervations of JUPITER, 1711.

		Saturday, May 26.	
12 44 28	12 39 44	The Star mark'd 58 in *Serpentarius* of the *Britiſh* Catalogue paſs'd over	76 12 00
52 40	47 56	The Nebulous Stars mark'd *a* in *Sagittarius* paſs'd over ——	75 39 20
13 8 44	13 4 00	*Jupiter* paſs'd over ——	74 37 00
15 43	10 59	Star mark'd 11 of *Sagittarius* paſs'd over	72 5 20
		Jupiter's Right Aſcenſion 270.19.00	
		Diſtance from the North Pole 113.11.50	

Sunday,

Time by the Clock.	Time corrected.	*Sunday, May* 27, 1711.	Diſtance from the Zenith.
10 47 24	10 43 2	The middle Star of the Forehead of ♏, paſs'd over —	73 12 00
12 57 46	53 24	The Teleſcopical Star *c* preceding *Jupiter* paſs'd over —	75 7 50
13 4 22	13 00 00	*Jupiter* paſs'd over —	74 36 50
11 53	7 31	The Star mark'd 11 of *Sagit.* paſs'd over	72 5 20
		Jupiter's Right Aſcenſion 270.11.00	
		Diſtance from the North Pole 113.11.40	
		Sunday, June 3.	
10 15 41	10 10 45	The middle Star in the Front of *Scorpio* paſs'd over —	73 12 5
12 14 11	12 9 15	The Nebulous Stars *b* of *Sagit.* paſs'd over	75 10 20
12 17 09	12 12 13	The Nebulous Stars *a* of *Sagit.* paſs'd over	75 39 30
12 28 56	12 24 00	*Jupiter* paſs'd over —	74 38 00
13 8 36	13 03 40	The preceding Star in the Eye of *Sagit.* paſs'd over —	74 29 15
		Jupiter's Right Aſcenſion 269.15.00	
		Diſtance from the North Pole 113.12.50	
		Monday, June 4.	
10 11 51	10 7 19	The middle Star in the Front of *Scorpio* paſs'd over —	73 12 00
12 10 18	12 5 46	The Nebulous Stars *b* of *Sagit.* paſs'd over	75 10 20
12 24 32	12 20 00	*Jupiter* paſs'd over —	74 38 10
13 4 45	13 0 13	The preced. Star at *ν* in *Sagit.* paſs'd over	74 29 10
13 5 41	13 1 09	The ſubſequent Star at *ν* paſs'd over —	74 24 50
		Jupiter's Right Aſcenſion 269.07.00	
		Diſtance from the North Pole 113.13.00	
		Saturday, June 9.	
9 52 16	9 49 5	The middle Star in the Front of *Scorpio* paſs'd over —	73 11 55
11 50 44	11 47 33	The Nebulous Stars *b* paſs'd over —	75 10 15
12 2 11	11 59 00	*Jupiter* paſs'd over —	74 38 25
12 45 8	12 41 57	The preced. Star at *ν* in *Sagit.* paſs'd over	74 29 10
		Jupiter's Right Aſcenſion 268.25.00	
		Diſtance from the North Pole 113.13.15	
		Sunday, June 10.	
9 48 22	9 44 38	The middle Star in the Front of *Scorpio* paſs'd over —	73 12 00
11 46 51	11 43 07	The Nebulous Stars *b* paſs'd over —	75 10 15
11 57 44	11 54 0	*Jupiter* paſs'd over —	74 38 35
12 41 14	12 37 30	The preced. Star at *ν* in *Sagit.* paſs'd over	74 29 15
		Jupiter's Right Aſcenſion 268.16.45	
		Diſtance from the North Pole 113.13.25	

Time by the Clock.	Time corrected.	*Saturday, July* 14, 1711.	Diſtance from the Zenith.
8 58 10	8 50 4	48 of *Serpentarius*, or C paſs'd over —	75 7 20
9 10 32	9 2 26	54 of the ſame, or D paſs'd over —	72 56 00
9 21 6	9 13 00	*Jupiter* paſs'd over ———	74 37 50
9 40 49	9 32 43	μ in the Bow of *Sagittary* paſs'd over	72 31 30
		Jupiter's Right Aſcenſion 264.12.30	
		Diſtance from the North Pole 113.12.40	
		Sunday, July 15.	
8 54 8	8 46 24	C of *Serpentarius* paſs'd over ———	75 7 20
9 6 28	8 58 44	D of *Serpentarius* paſs'd over ———	72 56 00
9 16 44	9 9 00	*Jupiter* paſs'd over ———	74 37 50
9 36 46	9 29 2	μ of *Sagittarius* paſs'd over ———	72 31 35
		Jupiter's Right Aſcenſion 264.07.45	
		Diſtance from the North Pole 113.12.40	
		Tueſday, July 3, 1712.	
11 36 3	12 25 14	σ under the Eye of *Capricorn* paſs'd over	71 24 40
12 44 6	12 35 17	π in *Capricorn*'s Noſe paſs'd over ——	70 33 00
12 45 42	12 34 53	ρ in *Capricorn* paſs'd over ———	70 09 50
12 57 49	12 47 00	*Jupiter* paſs'd over ———	71 26 20
13 16 24	13 5 35	20 in *Capricorn* by the *Britiſh* Catalogue paſs'd over ——	71 33 10
		Jupiter's Right Aſcenſion 306.09.20	
		Diſtance from the North Pole 110. 0.30	
		Thurſday, July 15.	
11 39 34	11 39 33	σ in *Capricorn* paſs'd over ———	71 24 45
55 1	11 55 00	*Jupiter* paſs'd over ———	71 49 20
12 19 53	12 19 52	20 in *Capricorn* paſs'd over ———	71 33 10
24 38	12 24 57	*n* in the Body of *Capricorn* paſs'd over	72 23 25
		Jupiter's Right Aſcenſion 304.34.35	
		Diſtance from the North Pole 110.23.30	
		Wedneſday, Sept. 17.	
7 32 37	7 31 56	The Teleſcopic Star preceding *Jupiter* paſs'd over — —	72 40 40
7 38 41	7 38 00	*Jupiter* paſs'd over ———	72 51 10
7 42 28	7 41 37	The Teleſcopic Star following *Jupiter* paſs'd over —	73 14 40
		Jupiter's Right Aſcenſion 299.43.00	
		Diſtance from the North Pole 111.25.30	
		Friday, Sept. 19.	
7 30 55	7 32 00	*Jupiter* paſs'd over ———	72 50 45
8 19 47	8 20 52	*n* in *Capricorn* paſs'd over ———	72 23 40
		Jupiter's Right Aſcenſion 299.45.00	
		Diſtance from the North Pole 111.25.05	

Time by the Clock.	Time corrected.	*Monday, Octob.* 6, 1712.	Diſtance from the Zenith.
6 25 35	6 31 30	*Jupiter* paſs'd over ——	72 39 50
6 36 22	6 42 17	ο in *Capricorn*'s *Noſe* paſs'd over ——	70 56 25
6 46 36	6 52 31	υ in *Capricorn*'s *Neck* paſs'd over ——	70 33 30
		Jupiter's Right Aſcenſion 300.39.00	
		Diſtance from the North Pole 111.14.10	
		Obſervations of MARS, 1711.	
		Sunday, Jan. 7.	
12 40 35	12 38 56	The Southern Star at ο in *Cancer* paſs'd over —— ——	35 04 00
12 40 56	12 39 17	The Northern Star at ο in *Cancer* paſs'd over —— ——	34 48 00
12 58 45	12 57 6	The ſubſequent Star at π in *Cancer* paſs'd over —— ——	35 21 20
13 27 15	13 25 36	ψ in the *Lyon* paſs'd over ——	36 8 50
13 50 52	13 49 13	The Southern Star at η in the *Lion's Neck* paſs'd over ——	33 19 00
14 00 39	13 59 00	*Mars* paſs'd over ——	34 51 30
14 30 14	14 28 35	*k* the Northern Star in the *Lion's Belly* paſs'd over —— ——	35 45 40
		Mars's Right Aſcenſion 150.20.00	
		Diſtance from the North Pole 73.23.35	
		Saturday, Jan. 27.	
10 40 59	10 41 30	20 of *Cancer*, or the firſt at *d* paſs'd over	32 14 10
10 50 16	10 50 47	η in *Cancer* paſs'd over ——	30 4 35
12 8 29	12 9 00	*Mars* paſs'd over ——	32 14 00
12 25 27	12 25 58	η the Southern Star in the *Lion's Neck* paſs'd over —— ——	33 19 00
12 37 59	12 38 30	γ the bright Star in the *Lion's Neck* paſs'd over —— ——	30 11 50
		Mars's Right Aſcenſion 143.37.00	
		Diſtance from the North Pole 70.36.00	
		Monday, Jan. 29.	
12 1 50	11 59 00	*Mars* paſs'd over —— ——	31 58 50
12 21 58	12 19 08	η in the *Lion* paſs'd over ——	33 19 05
12 34 31	12 31 41	γ the bright Star in the *Lion's Neck* paſs'd over —— ——	30 11 50
		Mars's Right Aſcenſion 142.49.30	
		Diſtance from the North Pole 70.30.50	

Time by the Clock.	Time corrected.	*Tueſday, Jan.* 30, 1711.	Diſtance from the Zenith.
10 33 30	10 30 25	20 of *Cancer*, or firſt at *d* paſs'd over	32 14 10
10 42 35	10 39 30	of *Cancer* paſs'd over ——	30 4 45
11 56 5	11 53 00	*Mars* paſs'd over — —	31 51 35
12 17 49	12 14 44	η in the *Lion* paſs'd over —	33 19 5
12 30 20	12 27 15	γ in the *Lion* paſs'd over ——	30 11 50
		Mars's Right Aſcenſion 142.25.00	
		Diſtance from the North Pole 70.23.35	
		Wedneſday, Feb. 28.	
8 27 11	8 23 58	μ in the Northern Foot of *Cancer* paſs'd over —— —	29 5 40
9 2 50	8 59 37	γ the *Northern Aſs* paſs'd over —	29 00 20
9 31 13	9 28 00	*Mars* paſs'd over — —	30 5 10
10 27 28	10 24 15	η in the *Lion* paſs'd over —	33 19 55
10 39 39	10 36 26	γ in the *Lion* paſs'd over ——	30 12 5
		Right Aſcenſion of *Mars* 133.45.00	
		Diſtance from the North Pole 68.37.10	
		Thurſday, March 1.	
8 22 47	8 19 27	μ in *Cancer* paſs'd over —	29 5 35
8 58 2[illegible]	8 55 8	The *Northern Aſs* paſs'd over —	29 00 15
9 26 20	9 23 00	*Mars* paſs'd over ——	30 6 20
10 23 04	0 19 44	η in the *Lion* paſs'd over —	33 19 50
10 35 36	10 32 16	The bright Star in the *Lion's Neck* paſs'd over ——	30 12 00
		Right Aſcenſion of *Mars* 133.37.30	
		Diſtance from the North Pole 68.38.20	
		Monday, Nov. 17, 1712.	
18 21 7	18 19 52	55 in the *Lion* (*Britiſh* Catalogue) paſs'd over — —	43 45 40
18 25 53	18 24 38	*c* under the *Lion's Belly* paſs'd over —	43 49 40
18 30 14	18 28 59	χ in the *Lion* paſs'd over —	42 35 10
18 43 15	18 42 00	*Mars* paſs'd over — —	43 7 25
		Right Aſcenſion of *Mars* 165.48.00	
		Diſtance from the North Pole 81.39.45	
		Thurſday, Nov. 20.	
18 13 8	18 6 40	55 in the *Lion* paſs'd over —	43 45 40
18 17 53	18 11 25	58 or *c* in the *Lion* paſs'd over ——	43 49 50
18 22 14	18 15 46	χ in the *Lion* paſs'd over —	42 35 15
18 38 18	18 31 50	σ in the *Lion*'s *Ham* paſs'd over ——	43 52 10
18 40 28	18 34 00	*Mars* paſs'd over — —	43 36 55
		Mars's Right Aſcenſion 167. 6.30	
		Diſtance from the North Pole 82. 9.15	

—*of the* Sun.

Obſervations of the SUN, 1711.	Diſtance from the Zenith.
Saturday, Jan. 6.	
The Sun's Center paſſing through the Plain of the Meridian, his remote and ſouthern Limb was diſtant from the Zenith — —	72 31 10
Friday, Jan. 26.	
The neareſt Limb of the Sun in the Meridian from the Zenith — — —	66 35 10
Tueſday, Jan. 30.	
The neareſt Limb of the Sun from the Zenith —	65 38 40
Monday, June 4.	
The remote Limb of the Sun from the Zenith —	28 24 18
Saturday, July 14.	
The remote Limb of the Sun — —	31 55 20
Tueſday, Nov. 20.	
The remote Limb of the Sun — —	73 30 40
Tueſday, Dec. 4.	
The remote Limb of the Sun from the Zenith —	74 59 30
Wedneſday, Jan. 2, 1712.	
The Sun's remote Limb from the Zenith —	73 17 30
Saturday, Jan. 12.	
The Sun's remote Limb — —	71 18 00
Friday, March 7.	
The Sun's remote Limb — —	52 31 00
Friday, May 9.	
The Sun's remote Limb — — —	31 40 50
Tueſday, October 7.	
The Sun's remote Limb from the Zenith —	61 29 50

—*of the* Moon.

Obſervations of the MOON, 1711.

Time by the Clock.	Time corrected.	*Saturday, May* 19, 1711.	Diſtance from the Zenith.
10 22 12	10 18 32	γ in *Scorpio* or 15 of *Libra* paſs'd over	75 32 50
10 50 55	10 47 15	The *Moon's* Limb paſs'd over, the Center being from the Zenith —	75 38 40
10 52 10	10 48 30	The *Moon's* Center paſs'd over, the neareſt Limb being diſtant —	75 22 00
11 8 30	11 4 50	*b* in *Scorpio* paſs'd over —	76 15 20
11 11 10	11 7 30	A in *Scorpio* paſs'd over —	75 50 55
		The *Moon's* Right Aſcenſion 229.18.30	
		Diſtance from the North Pole 114.13.40	

Time by the Clock.	Time corrected.	*Monday*, *Nov*. 19, 1711.	Diſtance from the Zenith.
16 41 28	16 36 8	The Center of the Moon paſs'd over, the remote Limb being ——	37 6 30
17 42 16	16 36 56	The Limb of the Moon paſs'd over, the Center being diſtant ——	36 52 30
16 46 20	16 41 00	*Saturn* paſs'd over —— ——	34 8 00
16 59 31	16 54 11	A Teleſcopic Star *a* paſs'd over ——	33 45 30
17 29 53	17 24 33	η in the South. Neck of the *Lion* paſs'd over	33 18 30
		Moon's Right Aſcenſion 135.41.40	
		Diſtance from the North Pole 75.23.20	
		Saturday, *Jan*. 12, 1712.	
7 40 50	7 34 00	The Middle of the Lunar Eclipſe, at what Time the Chord of the eclipſed Part of the Moon was 24. 30: but the greateſt Defect on the Northern Side was 8. 30. The Moon's Diameter 30.48	
11 39 52	11 33 6	ζ in *Cancer* (accord. to *Bayer*) paſs'd over	32 52 10
12 13 46	12 7 00	The Center of the Moon paſs'd over, the remote Limb being ——	34 14 10
40 46	12 34 00	*Saturn* paſs'd over —— ——	33 12 00
43 16	12 36 30	The Subſequent to π in *Cancer* paſs'd over	35 22 20
13 36 44	13 29 58	The *Lion*'s *Heart* paſs'd over ——	38 6 55
		Moon's Right Aſcenſion 127.25.30	
		Diſtance from the North Pole 71.31.00	
		Thurſday, *March* 6.	
7 39 8	7 38 8	80 in *Gemini* (*Brit*. Catal.) paſs'd over	30 29 30
7 49 42	7 48 42	86 or *l* in *Gemini* paſs'd over ——	30 51 45
7 54 45	7 53 45	The Limb of the Moon paſs'd over, the Center being diſtant ——	30 50 40
7 55 48	7 54 48	The Moon's Center paſs'd over, the neareſt Limb being ——	30 35 30
8 1 41	8 0 41	μ or 9 of *Cancer* paſs'd over —	29 4 55
		Moon's Right Aſcenſion 116.14.40	
		Diſtance from the North Pole 69.22.50	
		Wedneſday, *May* 7.	
9 47 38	9 46 2	70 of *Virgo* (*Brit*. Cat.) paſs'd over ——	66 9 50
9 48 48	9 47 12	71 of *Virgo* paſs'd over —— ——	65 45 30
9 52 51	9 51 15	75 of the ſame paſs'd over ——	68 7 40
10 9 36	10 8 00	The Moon's Limb paſs'd over, the Center being —— ——	69 12 30
10 10 43	10 9 7	The Center of the Moon paſs'd over, the remote Limb being ——	69 28 35
		Moon's Right Aſcenſion 208. 4.30	
		Diſtance from the North Pole 107.45.50	

Time by the Clock.	Time corrected.	*Thurſday, May* 8, 1712.	Diſtance from the Zenith.
10 52 2	10 50 00	8 in *Libra* (*Brit.* Cat.) paſs'd over ——	74 51 50
11 1 35	10 59 33	γ in *Scorpio*, or 15 in *Libra*, paſs'd over	75 32 30
11 8 2	11 6 00	The Moon's Limb paſs'd over, the Center being —— ——	73 42 30
11 09 16	11 7 14	The Moon's Center paſs'd over, the remote Limb being diſtant ——	73 58 20
11 50 33	11 48 31	A in *Scorpio* paſs'd over ——	75 51 10
11 57 34	11 55 32	δ or the middle Star in the Front of *Scorpio* paſs'd over ——	73 12 10
		Moon's Right Aſcenſion 223.45.00	
		Diſtance from the North Pole 112.16.10	
		Saturday, May 10.	
12 18 05	12 16 30	*Antares* or the *Scorpion's Heart* paſs'd over	77 10 00
13 3 48	13 2 13	A in *Serpentarius* paſs'd over ——	77 32 50
13 18 13	13 16 38	The Moon's Center paſs'd over, the Limb being diſtant ——	78 1 30
13 19 30	13 17 55	The Limb of the Moon paſs'd over, the Center being diſtant ——	77 46 05
13 35 25	13 33 50	*p* the firſt in *Sagittary* paſs'd over ——	79 4 20
14 16 8	14 14 33	λ in *Sagittary* paſs'd over ——	76 57 00
		The Moon's Right Aſcenſion 258.03.20	
		Diſtance from the North Pole 116.20.15	

N. B. *In the Copy of the Obſervations,* Ann. 1712. *ſent by Mr.* Flamſteed *to the Royal Society, the Name of the Obſerver ſeem'd to be eraſed out of the Title; and by his own Order theſe Words were ſubſcribed at the Bottom of the Page.*

Obſerved and tranſcribed by Joſ. Croſthaite.

XXVI.

Obſervations *on the* Heavens, 1713. *at* Greenwich, n. 344. p. 285.

— *of* Saturn.

Obſervations of SATURN, 1713.

Time by the Clock.	Time corrected.	*Sunday, Jan.* 25.	Diſtance from the Zenith.
h. ′ ″	h. ′ ″		° ′ ″
8 30 15	8 28 5	The Star before *Gemini* paſs'd over ——	28 13 20
8 41 7	38 57	*Caſtor's Foot* or η paſs'd over ——	28 54 50
8 49 8	8 46 58	His Heel or μ paſs'd over ——	28 50 40
12 10 49	12 8 39	ψ in the *Lion* (accord. to *Bayer*) paſs'd over	36 9 30
12 25 24	23 14	ν in the *Lion* paſs'd over ——	37 40 30
12 34 21	32 11	The Center of *Saturn* paſs'd over ——	36 51 45
12 35 44	12 33 34	The *Lion's Heart* paſs'd over ——	38 7 00
		Saturn's Right Aſcenſion 147.55.10	
		Diſtance from the North Pole 75.23.55	
		Longitude of ♌ —— 25. 8.15	
		~~Latitude North~~ —— ~~1.31.27~~	

Time by the Clock.			Time corrected.			*Thurſday*, *Feb.* 5, 1713.	Diſtance from the Zenith.		
h.	′	″	h.	′	″		°	′	″
11	20	52	11	14	10	ξ in the *Lion* (*Bayer*) paſs'd over ——	38	55	20
	30	9		23	27	ο in the *Lion* paſs'd over ——	40	17	30
	35	18		28	36	16 of the *Lion* (Cat. *Brit.*) paſs'd over	38	21	20
	47	8		40	26	ν in the *Lion* paſs'd over ——	37	40	30
	52	42		46	00	The Center of *Saturn* paſs'd over —	36	32	50
11	57	25		50	43	The *Lion's Heart* paſs'd over — —	38	7	5
12	0	35		53	53	31 in the *Lion* paſs'd over —— ——	36	42	50
	5	40	11	58	58	34 in the *Lion* paſs'd over ——	36	19	30
12	10	50	12	4	8	38 in the *Lion* paſs'd over ——	35	3	50
						Saturn's Right Aſcenſion 147. 4.45			
						Diſtance from the North Pole 75. 5.00			
						Longitude of ♌ 24.14. 8			
						Latitude North 1.32.16			
						Friday, *Feb.* 6.			
8	22	53	8	14	43	γ in *Gemini*, or the bright Foot of *Pollux* paſs'd over ——	34	52	00
11	29	22	10	21	12	ψ in the *Lion* paſs'd over ——	36	9	15
11	43	58	11	35	48	ν in the *Lion* paſs'd over ——	37	40	30
11	49	10	11	41	0	The Center of *Saturn* paſs'd over —	36	31	00
						Saturn's Right Aſcenſion 146.59. 0			
						Diſtance from the Pole 75. 3.10			
						Longitude of ♌ 24. 8.17			
						Latitude North 1.32. 8			
						Wedneſday, *Feb.* 18.			
11	0	15	10	53	0	The Center of *Saturn* paſs'd over —	36	12	00
11	8	53	11	1	38	The *Lion's Heart* paſs'd over —	38	7	5
11	17	7	11	9	52	The 34 in the *Lion* (*Brit.*Cat.) paſs'd over	36	19	35
11	22	16	11	15	1	38 of the ſame paſs'd over — —	35	3	55
						Saturn's Right Aſcenſion 146. 5.00			
						Diſtance from the Pole 74.44.10			
						Longitude of ♌ 23.12.47			
						Latitude North 1.32.41			
						Monday, *March* 2.			
10	6	30	9	52	3	ψ in the *Lion* paſs'd over —	36	9	30
	19	27	10	5	00	Center of *Saturn* paſs'd over ——	35	55	20
	31	21		16	54	*Lion's Heart* paſs'd over ——	38	7	5
	34	31		20	4	31 of the *Lion* paſs'd over ——	36	42	50
10	39	35	10	25	8	34 of the *Lion* paſs'd over ——	36	19	40
						Saturn's Right Aſcenſion 145.16.00			
						Diſtance from the Pole 74.27.30			
						Longitude of ♌ 22.22.40			
						Latitude North 1.23.52			

Tueſday

Time by the Clock.	Time corrected.	*Tueſday, April* 7, 1713.	Diſtance from the Zenith.
h. ′ ″	h. ′ ″		° ′ ″
7 43 1	7 41 15	ψ of the *Lion* paſs'd over	36 9 25
50 46	7 49 00	The Center of *Saturn* paſs'd over	35 31 10
57 36	55 50	ν of the *Lion* (*Bayer*) paſs'd over	37 40 20
8 6 39	8 4 53	η in the *Lion's Neck* paſs'd over	33 19 25
16 7	14 21	34 of the ſame (*Brit*. Cat.) paſs'd over	36 19 30
8 21 17	8 19 31	38 of the ſame paſs'd over	35 3 50
		Saturn's Right Aſcenſion 143.57.45	
		Diſtance from the Pole 74. 3.15	
		Longitude of ♌ 21. 3.32	
		Latitude 1.21.20	
		Wedneſday, April 8.	
7 47 43	7 46 00	The Center of *Saturn* paſs'd over	35 31 15
54 34	52 51	ν in the *Lion* paſs'd over	37 40 20
8 3 37	8 1 54	η in the *Lion* paſs'd over	33 19 20
13 4	11 21	34 of the *Lion* paſs'd over	36 19 35
8 18 14	8 16 31	38 of the *Lion* paſs'd over	35 3 45
		Saturn's Right Aſcenſion 143.57.30	
		Diſtance from the Pole 74. 3.20	
		Longitude of ♃'s ♌ 21. 3.20	
		Latitude 1.31.10	

Saturn was almoſt Stationary.

		Thurſday, Nov. 5.	
18 22 00	18 15 37	π in the ſubſequent Knee of the *Lion* paſs'd over	42 4 00
30 8	23 45	The *Lion's Heart* paſs'd over	38 7 5
54 35	48 12	ρ in the *Lion's Shoulder* paſs'd over	40 42 0
19 11 5	19 4 42	*l* in the *Lion's Belly* paſs'd over	39 25 15
19 26 23	19 20 00	The Center of *Saturn* paſs'd over	42 10 40
		Saturn's Right Aſcenſion 162.23.20	
		Diſtance from the Pole 80.43.00	
		Lontitude, *Virgo* 10.13.40	
		North Latitude 1.39.37	

—*Of* Jupiter.

Obſervations of JUPITER, 1713.

Time by the Clock.	Time corrected.	*Sunday, Aug.* 9.	Diſtance from the Zenith.
h. ′ ″	h. ′ ″		° ′ ″
12 40 4	12 37 27	λ in the Running Water of *Aquarius* paſs'd over —— ——	60 32 50
12 48 37	12 46 0	The Center of ♃ paſs'd over ——	60 48 35
12 52 36	12 49 59	73 of *Aq.* (*Brit.* Cat.) 1 at *b* paſs'd over	60 46 20
13 4 21	13 1 44	χ in the Water of *Aquarius* paſs'd over	60 49 10
		Jupiter's Right Aſcenſion 341.33. 5	
		Diſtance from the North Pole 99.21.40	
		Longitude ♓ 9.26.00	
		Southern Latitude 1.25.08	
		Monday, Aug. 10.	
12 36 21	12 33 55	λ in *Aquarius* paſs'd over ——	60 32 50
12 44 26	12 42 00	The Center of *Jupiter* paſs'd over ——	00 52 00
12 48 53	12 46 27	73 of *Aquary* paſs'd over ——	
		Jupiter's Right Aſcenſion 341.26. 5	
		Diſtance from the Pole 99.25. 5	
		Jupiter's Longitude ♓ 9.18.17	
		Southern Latitude 1.25.40	
		Monday, Oct. 26.	
7 29 16	7 28 42	σ in the Buttock of *Aquary* paſs'd over	63 34 40
7 36 34	7 36 0	*Jupiter*'s Center paſs'd over ——	63 00 5
8 14 34	8 14 0	80 of *Aquary*, firſt at ψ, paſs'd over —	62 5 20
8 17 45	8 17 11	84 of *Aquary* ſubſequent at ψ, paſs'd over	62 37 5
		Jupiter's Right Aſcenſion 335.41.30	
		Diſtance from the Pole 101.33.20	
		♃ Longitude ♓ 3.16.00	
		South Latitude 1.19. 8	
		Tueſday, Oct. 27.	
7 25 40	7 23 34	σ in the Buttock of *Aquary* paſs'd over	63 34 35
7 33 6	7 31 00	*Jupiter*'s Center paſs'd over ——	62 59 15
8 11 00	8 8 54	Firſt at ψ of *Aquary* paſs'd over ——	62 5 15
8 14 10	8 12 4	Subſequent at ψ paſs'd over ——	62 37 10
		Jupiter's Right Aſcenſion 335.43.20	
		Diſtance from the Pole 101.32.30	
		Jupiter's Longitude ♓ 3.17.58	
		Southern Latitude 1.19.00	

Thurſday,

Time by the Clock.	Time corrected.	*Thurſday, Oct.* 29, 1713.	Diſtance from the Zenith.
h. ′ ″	h. ′ ″		° ′ ″
7 18 29	7 15 19	σ in *Aquarius* paſs'd over ——	63 34 40
26 10	7 23 00	*Jupiter*'s Center paſs'd over ——	62 57 20
8 3 47	8 0 37	The firſt at ♃ paſs'd over ——	62 5 20
6 55	8 3 45	The Subſequent at ♃ paſs'd over ——	62 37 10
		Jupiter's Right Aſcenſion 335.47.45	
		Diſtance from the Pole 101.30.35	
		Jupiter's Longitude ♓ 3.22.41	
		Southern Latitude 1.18.49	
		Obſervations of MARS, 1713.	
		Wedneſday, Feb. 18.	
12 28 38	12 21 20	τ in the *Lion*'s *Ham* paſs'd over ——	47 2 15
12 51 6	12 43 48	β in the Bending of ♍ Wing paſs'd over	48 5 40
13 10 21	13 3 3	10 of *Virgo* (*Brit.* Cat.) *r* paſs'd over	47 57 40
13 13 18	13 6 00	The Center of *Mars* paſs'd over ——	47 2 5
13 21 8	13 13 50	*c* in the *Virgin*'s *Neck* paſs'd over ——	46 33 30
		Mars's Right Aſcenſion 179.29.20	
		Diſtance from the Pole 85.34.35	
		Longitude, *Virgo* 27.46.00	
		Northern Latitude 3.51.10	
		Tueſday, March 3.	
11 55 52	11 53 2	ν in the *Virgin*'s *Neck* paſs'd over ——	43 20 00
12 4 50	12 2 00	The Center of *Mars* paſs'd over ——	45 14 20
10 54	8 4	π in the *Virgin*'s *Face* paſs'd over ——	43 15 25
20 8	17 18	11 of the *Virgin*'s paſs'd over ——	44 3 30
12 30 25	27 35	16 of *Virgo c* in the Neck paſs'd over	46 33 25
12 32 37	12 29 47	17 of *Virgo* (*Brit.* Cat.) paſs'd over ——	44 33 45
		Right Aſcenſion of *Mars* 175. 1.15	
		Diſtance from the North Pole 83.46.45	
		Longitude, *Virgo* 22.57.33	
		Northern Latitude 3.43.37	

— *of* Mars.

Time by the Clock.			Time corrected.			*Tueſday, April* 7, 1713.	Diſtance from the Zenith.		
h.	′	″	h.	′	″		°	′	″
9	4	47	9	3	10	χ under the *Lion*'s *Belly* paſs'd over	42	35	25
9	17	37	9	16	00	The Center of *Mars* paſs'd over	42	42	50
9	38	10	9	36	33	The firſt of *Virgo* (*Brit.* Cat.) α paſs'd over	41	44	50
9	45	00	9	43	23	The Northern Star in the Head of *Virgo* ξ paſs'd over	41	37	15
						The Right Aſcenſion of *Mars* 165.45.40			
						Diſtance from the Pole 81.15.10			
						Longitude of *Mars*, ♍ 13.30.40			
						Northern Latitude 2.26.31			
						Wedneſday, April 8.			
9	1	44	9	0	29	χ of the *Lion* paſſes over	42	35	30
9	14	15	9	13	00	The Center of *Mars* paſſes over	42	43	40
9	35	7	9	33	52	α of the *Virgin* paſſes over	41	44	55
9	41	58	9	40	43	ξ of the *Virgin* paſſes over	41	37	15
						The Right Aſcenſion of *Mars* 165.41.00			
						Diſtance from the Pole 81.16.00			
						The Longitude of *Mars,Virgo* 13.26.45			
						Northern Latitude 2.23.58			
						Friday, May 1.			
7	55	9	7	50	00	The Center of *Mars* paſſes over	44	17	30
8	18	12	8	13	3	ν in the *Virgin*'s *Head* paſſes over	43	20	00
8	33	14	8	28	5	π in the *Virgin*'s *Face* paſſes over	43	15	30
						The Right Aſcenſion of *Mars* 166.59.40			
						Diſtance from the Pole 82.49.50			
						Longitude, *Virgo* 15.15.00			
						Northern Latitude 1.27.40			
						Saturday, May 2.			
7	52	45	7	47	00	The Center of *Mars* paſſes over	44	24	20
8	15	7	8	9	22	ν in *Virgo*'s *Head* paſſes over	43	20	5
8	30	8	8	24	23	π in *Virgo*'s *Face* paſſes over	43	15	25
						Mars's Right Aſcenſion 167.10.00			
						Diſtance from the Pole 82.56.40			
						Longitude, *Virgo* 15.27. 5			
						North Latitude 1.25.20			

Ob-

—*of the* Moon.

Obſervations of the MOON, 1713.

Time by the Clock.	Time corrected.	*Sunday, Jan.* 25, 1713.	Diſtance from the Zenith.
h. ′ ″	h. ′ ″		° ′ ″
8 9 33	8 7 23	The Teleſcopic Star *a* paſſes over ——	28 26 20
8 15 5	8 12 55	123 of *Taurus* (in *Brit.* Cat.) paſſes over	27 2 30
8 20 20	8 18 10	The preceding Limb of the Moon paſſes over, the Center being diſtant from the Zenith —— ——	27 32 40
8 21 23	8 19 13	The Center of the Moon paſſes over, the Limb being diſtant from the Zenith	27 47 40
8 22 52	8 20 42	The Northern Cuſp of the Moon from the Zenith —— —	27 17 40
8 30 15	8 28 5	The Star before *Gemini* paſſes over —	28 13 20
8 41 7	8 38 57	η the Foot of *Caſtor* paſſes over ——	28 45 50
8 49 8	8 46 58	μ the Heel of the ſame paſſes over —	28 50 40
		The Right Aſcenſion of the Moon's Center 84.26.55	
		The viſible Diſt. from the Pole 66. 4.40	
		But taking in the Parallax 65.39.50	
		The Longitude of the Moon, ♊ 24.56.30	
		North Latitude 0.57.00	
		Monday, Jan. 26.	
8 26 41	8 24 36	The Star before *Gemini* paſſes over —	28 13 30
8 37 31	8 35 26	η the Foot of *Caſtor* paſſes over ——	28 54 50
8 45 31	8 43 26	μ the Heel of *Caſtor* paſſes over ——	28 50 40
9 9 43	9 7 38	The preceding Limb of the Moon paſſes over, the Center being from the Vertex —— —	28 45 00
9 10 50	9 8 45	The Center of the Moon paſſes over, the remote Limb being from the Vertex	29 0 5
9 12 30	9 16 25	The Northern Cuſp of the Moon is from the Vertex —— —	28 30 10
9 27 50	9 25 45	The 46 of *Gemini* (*Brit.*Cat.) paſſes over	28 26 10
9 42 44	9 40 39	λ in the Groin of *Gemini* paſſes over —	28 59 30
		The Right Aſcenſion of the Moon's Center 97.43.50	
		Diſt. from the Pole obſerved 67.17. 5	
		Taking in the Parallax 66.51.15	
		Longitude of the Moon, ♋ 7. 6.18	
		South Latitude 0. 8.48	

— *of* Jupiter's *Satellites.*

Obſervations of JUPITER'*s* Satellites.

						Friday, Oct. 30.
6	56	30	6	52	35	The fourth Satellite is ſeen emerging out of the Shadow, being diſtant from the Third near it on the Right Hand, by a Diameter of *Jupiter*; with a Tube of eight Foot.
7	4	00	7	00	0	It ſhined bright, and drawing a Line from that neareſt one through the Center of *Jupiter*, it left the emerging one to the South; but in an inverted Situation.
7	36	31	7	32	30	The Star in μ in *Pegaſus* paſs'd over the Arch of the Meridian.
						Saturday, Nov. 7.
7	13	2	7	5	00	The ſecond Satellite emerged, or rather began to emerge; in a Tube of eight Feet.
9	5	11	8	57	00	δ of the Conſtellation *Piſcas* in the Southern String paſs'd over.

N. B. *That Teleſcopic Star* a, *which* Jan. 25. *went before the Moon, then had its Right Aſcenſion* 81°. $28'\frac{1}{2}$, *and was diſtant from the Pole* 66°. 58′. 20″; *whence its Longitude was* ♊ 22°. $9'\frac{2}{3}$, *with Southern Latitude* 9°. $13'\frac{1}{2}$. *Now this is the very Star to which* Jupiter *applied in his ſecond Station*, Feb. 6, 1634, *and left it to the South not more than three Diameters of his own Body, according to the Obſervation of* Gaſſendus; *as is deliver'd in his Book*, p. 174. *And* Mars *was obſerved near the ſame*, Sept. 6, 1644, *in the Morning, as may be ſeen in the Prolegomena of* Hevelius *before his Selenographia*, p. 65. Fig. 1. *Now it will much conduce to the accurate Determination of* Jupiter'*s Node, and his Motion, if the Plain of his Orbit among the fixt Stars does not remain immoveable. For after the Term of* 83 *Years, in which* Jupiter *compleats ſeven Periods enough exact, that is*, An. 1717, Jan. 10, *in the Morning, the Planet will either cover that Star with his Body, or at leaſt will paſs very near it; a Sight very rare, nor yet granted, as I know on, to any Aſtronomer in regard to* Jupiter.

Vid. Infr. S. XXXI.

Now the Star itſelf, tho' called a Teleſcopic *Star, in a clear Sky and in the Abſence of the Moon, may be ſeen by the naked Eye, and has a Companion following it to the South, and diſtant about the Sun's Diameter; near which* Jupiter *will be ſeen cloſely joined*, July 20, *in the Morning, the preceding Year* 1716.

Obſervations *of the* Occultations *of the* fix'd Stars *by the* Moon, *uſeful for finding the* Longitude, *by* —— n. 354. p. 693.

XXVII. Of all the Methods hitherto propoſed for finding the *Longitudes* of Places for Geographical Uſes, none ſeems more adapted to the Purpoſe, than that by the *Occultations* of the fixed Stars by the

Moon obſerved in diſtant Places: For thoſe Immerſions of the Stars, which happen on the dark Semicircle of the Moon, and their Emerſions from the ſame, are perfectly momentaneous, without that Ambiguity, to which the Obſervations of the Eclipſes of the *Moon*, and thoſe of *Jupiter*'s *Satellites* are ſubject. Beſides, whilſt the Moon is horned, and her weaker Light leſs dazzling, an ordinary ſhort Teleſcope, ſuch as is found to be manageable on Ship-board, ſuffices to obſerve thoſe Moments, even in the Occultations of very minute Stars: On which Account, this Way ſeems to bid faireſt for finding the Longitude at Sea. But ſince it would be needleſs to enquire exactly what Longitude a Ship is in, when that of the Port to which ſhe is bound is ſtill unknown; it were to be wiſh'd, that the Princes of the Earth would cauſe ſuch Obſervations to be made in the Ports, and on the principal Head-Lands of their Dominions, as might once for all ſettle truly the Limits of the Land and Sea. This Work however, being likely to be left to the Care of private Perſons, it may not be amiſs to give Notice of the preſent Opportunity of performing it in this our Northern Hemiſphere, by Means of the frequent Appulſes of the Moon, to the more Southerly of the *Hyades*, many of which ſhe eclipſes in each monthly Revolution, and will continue ſo to do, during the Years 1718, 1719 and 1720.

Theſe Stars are but three or four in all former Catalogues, but the *Britiſh* of Mr. *Flamſteed* encreaſes them to Sixteen; to them we have added three others ſomewhat ſmaller, *viz.* *c*, *i*, and *n* in the Figure of Fig. 121. the *Hyades* hereto annexed. In it the principal Stars are mark'd with *Bayer*'s Marks, and the reſt with the Letters of the *Italick* Alphabet; their Longitudes are fitted to the Beginning of the Year 1718, and being truly laid down, may ſerve to inſtruct the Obſerver, when and where to look for them, when the Moon is among them.

It appears by this Scheme, that the Diſtance between *a* and α or *Palilicium*, is about nine Hours Motion of the Moon, in which Time, ſuppoſing her to paſs one to the other, ſhe muſt eclipſe γ and ε, and four or five of thoſe about θ, and muſt apply very cloſe, with her Southern Limb, to all thoſe, which have about ſix Degrees South Latitude; which would be a very entertaining Sight. But if the Times of the Occultations of any one of theſe Stars, or even of any two of them in the ſame Night, be accurately obſerved under diſtant Meridians, the Difference of thoſe Meridians may be truly obtained thereby; eſpecially ſince the *Moon's Parallax*, and all other Parts of her Theory thereto required, are at preſent ſufficiently ſtated and known.

For the Sake of ſuch, as are willing to make uſe of this Method, we have added the Places of all the *Hyades* fitted to the preſent Time, and chiefly taken from the *Britiſh* Catalogue, which being faulty in the Stars we call *k* and *l*, we have here rectified them.

A Catalogue of the Hyades, *for the Beginning of the Year* 1718.

Names of the Stars.		Long. ♊			South Lat.			Mag.
Which goes before γ in the Bull ———	a	0	51	3	5	50	14	7
In the Bull's Noſtrils, ——— *Bayer*	γ	1	50	54	5	46	22	3
That under γ ——— ———	b	1	56	31	6	19	57	7
In the End of the Bull's Noſe ———	c	2	54	25	4	47	5	7
Between the Noſtrils and the North Eye of the Bull ———	δ	2	54	47	4	0	34	3/4
Joyning this to the South ———	d	3	10	33	4	9	4	6
The Northern one of thoſe before θ ——	e	3	17	21	5	41	50	8
The bright Southern one of the ſame —	f	3	25	32	6	2	44	6
That which follows, δ —— ———	g	3	35	2	3	43	27	5
The Northern of the near ones between the Noſtrils and the Bull's Eye ———	θ	3	59	45	5	47	16	4
The more Southern one of the ſame —	θ	4	0	11	5	52	55	4
The Northern of the two above θ ———	h	4	2	32	5	23	43	7
The Southern one of the ſame ——	i	4	7	44	5	36	40	8
The firſt of the 3 in a right Line under θ	k	4	19	27	6	9	45	4/7
The Middlemoſt of the ſame ———	l	4	26	55	6	7	35	4/7
The Northern one of the two following θ	m	4	30	26	5	37	49	7
The Northern Eye of the Bull ———	ε	4	30	31	2	35	58	3
The Southern of thoſe following θ ——	n	4	32	35	5	41	00	8
The Subſequent of the 3 under θ ——	o	4	45	55	6	0	35	7
Palilicium, or the Bull's Eye, or α according to *Bayer*. ———	α	5	50	20	5	29	50	1
The next following this ———	p	6	17	35	6	3	20	7
The Southern of the contiguous ones following —— ——	q	6	30	34	6	19	19	6
The Northern one the brighter of the two	σ	6	33	12	6	12	35	7

An Account of the Cauſe *of* Venus *being* ſeen *in the* Day-time, *by* *Dr.* E. Halley. n. 349. p. 466.

XXVIII. The late Appearance of *Venus* in the *Day-time*, for many Days together, was generally taken Notice of about *London*, and elſewhere; and by ſome reckoned to be prodigious. This put me upon the Enquiry, how it came to paſs, that at that Time the *Planet* ſhould be ſo plainly ſeen by Day; whereas ſhe rarely ſhews herſelf ſo, unleſs to thoſe, who know exactly where to look for her. To reſolve this, the following Problem aroſe, *viz.* To find the Situation of the *Planet* in reſpect of the *Earth*, when the *Area* of the illuminated Part of her Disk is a *Maximum*.

To inveſtigate this *Maximum*, I found it requiſite to aſſume the following *Lemmata*. I. That the viſible *Areas* of the Diſk of the ſame *Planet*, at differing Diſtances, are always reciprocally as the Squares of thoſe Diſtances; which is evident from the firſt Principles of Opticks. II. That the *Area* of the whole Diſk of the *Planet* is to the *Area* of the enlightned Part thereof, as the Diameter of a Circle to the Verſed-Sine of the exteriour Angle at the *Planet*, in the Triangle, at whoſe Angles are the *Sun*, *Earth*, and *Planet*. III. That in all plain Triangles, four Times the Rectangle of the Sides containing any Angle, is to be the Exceſs of the Square of the Sum of the Sides above the Square of the Baſe, as the Diameter is to the Verſed-Sine of the Complement of the contained Angle to a Semicircle, which I call the exteriour Angle: This is a new *Theorem* of good Uſe in *Trigonometry*, and is eaſily to be proved from the 12*th* and 13*th* of the II. *Elem. Euclid.*

This premiſed, putting m for the Diſtance of the *Sun*, and *Earth*, and n for that of the *Sun* and *Venus*, and x for the Diſtance of the *Earth* and *Venus*, or the third Side of the Triangle which we ſeek; by the third *Lemma*, $4nx$, will be to the Exceſs of the Square of $n+x$ above the Square of m, as the *Area* of the whole Diſk of *Venus* to the *Area* of the Part enlightned; and by the *firſt Lemma*, the *Area's* of her whole Diſk, are at all times as the Squares of x reciprocally; whence the Quantity $\frac{nn+2nx+xx-mm}{4nx^3}$ will in all Caſes be proportional to the Area of the enlightned Part.

Now that this ſhould be a *Maximum*, it is required that the Fluxion thereof be equal to o, or that the negative Parts thereof be equal to the Affirmative; that is, that $\overline{2n\dot{x}+2x\dot{x}} \times 4nx^3 = 12n\dot{x}^2 x \times \overline{nn+2nx+xx-mm}$; and dividing all by $4nx^2\dot{x}$, the Equation becomes $2nx+2xx=3nn+6nx+3xx\underline{-3mm}$. Conſequently $3nn+4nx+xx=3mm$, and therefore $x=\surd\,3mm+nn - 2n$.

From hence a ready and not inelegant Geometrical Conſtruction becomes obvious; for with the Center S, and Radius $ST=m$, deſcribe the Semicircle TDA; and with the ſame Center and Radius $SE=n$, the Semicircle EVB; which two Semicircles ſhall repreſent the Orbs of the *Earth*, and *Venus*. Then make the Chord $AD=$ to the Radius ST, and from D towards A, lay off $DF=SE$; draw TF, and thereon place $FG=BE=2n$, and with the Center T and Radius TG deſcribe the Arch GV, cutting the Semicircle BVE in V; and Fig. 121.

and draw the Lines *SV*, *TV*; I ſay the Triangle *STV* is ſimilar to that, at whoſe Angles are the *Sun*, *Earth*, and *Venus*; at the Time when the *Area* of the inlighted Part of that Planet's Disk, as ſeen from the *Earth*, is greateſt. How this Geometrical Effection follows from the Equation is too evident to need repetition.

In conſequence then of this Solution, I find this *Maximum* always to happen, when the *Planet* is about 40 Degrees diſtant from the *Sun*; and the Times thereof, about the Middle between her greateſt Elongations on both Sides from him, and her retrograde Conjunctions with him; when little more than a Quarter of her viſible Disk is luminous, and reſembling the Moon of about 5 Days old; and tho' her Diameter is at that Time but 50 Seconds, yet ſhe ſhines with ſo ſtrong a Beam, as to ſurpaſs the united Light of all the fixt Stars that appear with her, and caſts a very ſtrong Shade on the Horizontal Plain, whereon they all ſhine; an irrefragable Argument to prove, that the Disks of the fixt Stars are inconceivably ſmall, and next to nothing; ſince ſhining with a *native* Light, ſo many of them do not equal the *reflex* Light of one quarter of a Disk of leſs than a Minute Diameter.

In this Situation *Venus* was found in *July* laſt, on the tenth Day; about which Time, when the *Sun* grew low, ſhe was very plainly ſeen in the Day Time, for ſeveral Days together; as ſhe might have been in the Mornings, about the latter End of *September*. But this, ariſing from the Cauſes we have now ſhewn, is nothing uncommon; for every eighth Year it returns again, ſo that the *Planet* may be ſeen on the ſame Day of the Month and Hour, very nearly in the ſame Place.

Laſtly, It may not be amiſs to note, that the Equation $x = \sqrt{3mm+nn}-2n$ has a Limit; for if n be equal to $\frac{1}{4}m$, the Point *V* will fall on *B*; and the whole Disk of a Planet at that Diſtance from the *Sun* would be the *Maximum*, *viz.* when in its ſuperior Conjunction with the Sun. And the like if n were leſs than $\frac{1}{4}m$; the Arch *GV* in ſuch Caſe not interſecting the Semicircle *BE*.

XXIX.

The Occultation *of a* Star *by the* Moon; *and an* Eclipſe *of the* Moon *following it.* Nov. 21, O.S. 1713. *by Mr.* F. Blanchin, n. 340. p. 88.

Hours after Noon.
h. ′ ″ A Star in *Taurus*, by *Bayer*, mark'd τ, nearly apply'd it
ſelf to the Limb of the Moon; obſerv'd by a Teleſcope of
12 53 34 twelve Palms.

It was now hid by that Part of the Moon's Limb, which
12 54 34 is almoſt in the Middle between the Spots of *Ariſtarchus* and *Galileus*. The diurnal Parallel deſcrib'd by the Moon's Center appears more to the South than the Star τ by $7\frac{1}{2}$ Parts of the Micrometer, ſuch as the Diameter of the Moon ſubtends 37. Therefore the Declination of the Star τ is more to the North than the apparent Declination of the Moon's Center, by about $5\frac{1}{2}$ Minutes of a great Circle.

14 0 14 *Sirius* came to the Meridian, by which the Times were verified.

The

h.	′	″	
14	32	57	The Star τ, which had emerged ſome Minutes out of the Moon's Limb, in its diurnal Revolution precedes the Weſtern Limb of the Moon by 33 Seconds of Time, and it precedes the Center of the Moon by 103 Seconds, or 1′. 43″.
14	42	50	The ſame precedes the Limb of the Moon by 48″, and the Center by 1′. 58″.
14	50	37	The Difference of Right Aſcenſion of the Star and of the Limb is 1′. 03″. But of the Center of the Moon and the ſame Star is 2′. 13″.
15	0	0	The Penumbra in the Limb of the Moon, which before was pretty dilute, is now become ſenſibly denſer.
15	2	20	The Penumbra is more apparent, but the true Shadow does not yet appear.
15	4	20	The Beginning of the Incidence of the Moon into the true Shadow, on that Part of the Limb which is next to the Spot *Schickard.*
15	5	21	The true Shadow now covers one Part, ſuch as the Diameter of the Moon in the Micrometer makes 37.
15	7	20	Now two ſuch Parts of the Moon's Diameter are cover'd as make 37.
15	16	20	Now $\frac{5}{37}$ Parts of the Moon's Diameter are cover'd.
15	31	20	Now $\frac{9}{37}$ of the Moon's Diameter are hid.
16	12	0	Now $\frac{12}{37}$ Parts are conceal'd.
16	17	20	The latent Parts are 15 as before.
16	50	20	Now the latent Parts are $\frac{17}{37}$.
16	54	35	The firſt Limb of *Tycho* begins to emerge.
16	56	9	Now all *Tycho* emerges.
17	13	30	Five Parts of 37 of the Moon's Diameter lye hid.
17	27	45	The true Shadow comes out of the Limb of the Moon, in a Place mark'd out by drawing a Diameter between *Ariſtarchus* and *Plato.*

N. B. *This Obſervation is ſo much the more to be valued, becauſe the Occultation of the Star* τ *happens ſo near to the Sun's oppoſite Point, that his Place among the fixt Stars may from hence be truly examin'd.*

XXX. Having after Midnight carefully corrected the Clock by no leſs than ten Obſervations of the Altitude of the bright Star in *Aries*, the Error thereof was found 5′. 13″ too faſt, the Extremes not differing above 6″: And in the Morning about 7^h, by as many Altitudes of the *Sun*, with a like Agreement, the ſame Error was found 5′. 14″ to be deducted from the Times ſhewn by the Clock.

The Occultation of Jupiter *by the Moon,* July 14. *in the Morning,* 1715, *at* Wanſted, *by Mr.* J. Pound, n. 347. p. 401.

July

July 13. P. M. N.	Time by the Clock.			Time corrected.		
	h.	′	″	h.	′	″
The third Satellite of *Jupiter* was hid by the Moon	13	27	33	13	22	20
The firſt Satellite was hid	13	32	35	13	27	22
The ſecond Satellite was hid	13	34	25	13	29	11
The firſt Contact of the Limbs of ♃ and ☾	13	34	54	13	29	41
Jupiter wholly hid	13	36	23	13	31	10
The third Satellite came out from behind the dark Side of the Moon	14	7	25	14	2	12
The firſt Satellite	14	12	25	14	7	12
The ſecond Satellite	14	14	38	14	9	25
The firſt Limb of *Jupiter* came out	14	14	45	14	9	32
The following Limb of ♃ or laſt Contact	14	16	15	14	11	2
The fourth Satellite emerged	14	18	49	14	13	36

Jupiter and the Satellites were to the Northward of the viſible way of the Moon's Center.

This Occultation was obſerved through a Teleſcope, in which the focal Length of the Object-Glaſs was 14½ Feet, and of the Eye-Glaſs 2¾ Inches. And the Aperture of the Object-Glaſs was 1 1/10 Inch.

I could perceive no Colours on *Jupiter*'s Limb, either at his Immerſion or Emerſion, when the Axis of the Tube was directed to him.

The Occultation *of a fixt* Star *in* Gemini *by* Jupiter, *Jan.* 11, O. S. 1717. &c. *by* —— n. 351. p. 546.

XXXI. Two Years * ago we gave Notice that *Jupiter* would cover a certain fixt Star with his Body, mentioning the tenth Day of *January* of this Year. But as *Jupiter* was almoſt Stationary, and ſomething farther advanced towards the Eaſt than by our Tables, the foreſaid Occultation did not happen till the eleventh Day; which becauſe of Clouds we could not obſerve at *London* as we wiſh'd.

Our Aſtronomers did not watch for it in vain. *Martin Folkes*, Eſq; at *London*, with ſome others of the Royal Society, on *Jan.* 11, at Eight at Night, ſaw the Center of *Jupiter* to follow the fixt Star at the Diſtance of one Diameter of his Body, which Star was more to the North of the ſaid Center by about ¾ of *Jupiter*'s Semidiameter. Afterwards Clouds intercepted *Jupiter*. Now taking an Account of *Jupiter*'s Motion he concluded, that the Star was in Conjunction with *Jupiter* after Midnight, and was cover'd by the Northern Part of his Diſk.

The Reverend *J. Theoph. Deſaguliers*, and Mr. *Stephen Grey*, at *Weſtminſter*, ſaw the fixt Star at Six in the Evening, when it was diſtant from *Jupiter*'s Limb his whole Diameter, towards the North Weſt. Whence, and from the Obſervations of the following Days, it appears that the Conjunction happen'd about Midnight.

* *Vid.* Supr. p. 298.

Alſo the Rev. Dr. *J. Pound* at *Wanſtead* made the following very accurate Obſervations, which were taken by a very long Tube with a Micrometer.

Jan. 5. at 5^h. 6′, equal Time, the Center of *Jupiter* was diſtant from the ſaid fixt Star 31′. 49″ : which at 5^h. 38′ it follow'd with 34′. 12″ of Right Aſcenſion. And at the ſame Time the Southern Limb of *Jupiter* had the ſame Declination with the Star.

On the ninth Day following at 6^h. 6′ the Center of *Jupiter* was diſtant from the Star 10′. 49″; and after 8 Minutes the Difference of Right Aſcenſions was 11′. 32″. And then the Center of the Planet was ſo little more Southerly than the Star, that the Difference could hardly be perceived.

On the eleventh Day at 5^h. 30′, equal Time, the Diſtance of their Centers was 1′. 24″, and at the ſame Time the Star was ſeen to be about a Quarter of *Jupiter*'s Diameter more to the North than his Center. Now the leaſt Diameter of *Jupiter* is found to be 0′. 43″. Then Clouds came on.

But upon the twelfth Day at 5^h. 17′. the Diſtance of the Centers was 3′. 7″. And at 5^h. 50′. *Jupiter* preceded the Star by 3′. 30″ of Right Aſcenſion. And at the ſame Time the Northern Limb of *Jupiter* had the ſame Declination as the fixt Star exactly.

Now by comparing theſe Obſervations it appears, that this fixt Star was in Conjunction with *Jupiter* on *Jan.* 11, at 13^h nearly, and was not more Northerly than his Center than 17″ or 18″, and therefore underwent an Occultation by him.

This fixt Star, tho' yet enter'd in no Catalogue, had its Place then in ♊ 22°. 13′, with South Latitude 0°. 13′½, and has a Companion more Northerly by 7 Minutes, which precedes him by 17 Minutes, or is in ♊ 21°. 56′, with South Latitude 0° 6′½, to which *Jupiter* was ſeen to be joined *Jan.* 16, at 6^h. 30′, in the Evening.

Thus in a Space of leſs than two Months *Jupiter* has corporally eclipſed two fixt Stars, of which Thing we have not one Inſtance ſince the Invention of the Teleſcope. Wherefore theſe Obſervations are to be laid up for the Uſe of Poſterity, among the moſt precious Curioſities of *Urania*.

Now our Star in the Year 1634, *Feb.* 6, was in Conjunction with *Jupiter* then ſtationary, and was more to the South than him by three of his Diameters; as *Gaſſendus* obſerved. Whence it will appear, by a due Calculation, that the Nodes of *Jupiter* as to Senſe have continued immoveable for the 83 Years laſt paſt; and that at two Signs, 8°. 35′, from the firſt Star of *Aries*.

The ſame Aſtronomers have been watchful of another Obſervation of a Tranſit of *Mars* near the Northern Star of the Forehead of *Scorpio*, which was not leſs remarkable. For *Mars* on *Feb.* 5, in the Morning, or the 4^{th}. 16^h. was ſeen ſo near the ſame Star, that it could not be perceived with the naked Eye; but by the Teleſcope it was found above

A Tranſit *of* Mars *below the* Northern Star *in the* Forehead *of* Scorpio, *Feb.* 5, 1717.

towards the Eaſt, and therefore *Mars* was not yet join'd with it. At 16^h. 10′, apparent Time, *Mars* was in a right Line with the Northern Star in the Forehead, and the Teleſcopic Star which follows it to the North, at the Diſtance of about 8 Minutes. At 16^h. 35′ *Mars* was intermediate in the right Line with the Northern Star, and that in the Middle of the Forehead; and after a Quarter of an Hour, with that in the Southern Part of the Forehead; ſo that at 16^h. 54′, apparent Time, it was eſtimated to be the very Conjunction as to Longitude, at what Time *Mars* with ſufficient Exactneſs was only two Minutes more to the South than the Star. Alſo Dr. *Pound* obſerved the Conjunction in reſpect of Right Aſcenſion to be 17^h. 25′, apparent Time, with the Diſtance of the Centers 2′. 7″. It was a pleaſant Sight to ſee *Mars* gradually approaching the Star, and manifeſtly to diſcover his Motion, tho' a very ſlow one.

With this let the Obſervation of our *Horrox* be compared, *An.* 1638, *Feb.* 7, in the Morning, as may be ſeen in his Letters, p. 304. For then *Mars* had an Appulſe to the ſame Star, and came much nearer it, but the Conjunction was over before his riſing.

To theſe add the Obſervation of *Saturn*, Jan. 25. 12^h. 25′, equal Time, made by Dr. *Pound*. Then the Planet was diſtant from the Star, which is the 58 of *Virgo* in the *Britiſh* Catalogue, 13′. 16″ towards the South, and follow'd it, with 2′. 30″. Right Aſcenſion. The Star was in ♎ 19°. 21′. 52″, with North Latitude 2°. 47′. 25″.

Emerſions *of the firſt* Satellite *of* Jupiter, *at* Rome, *&c.* 1713, *by Mr.* F. Blanchin, n. 340. p. 89.

XXXII. *Sept.* $\frac{11}{22}$, Afternoon 8^h. 38′. 20″, the inmoſt Satellite of *Jupiter* began to emerge over-againſt the Space which is extended between the two Belts of *Jupiter*. The Obſervation was made with a Teleſcope of Mr. *Andrew Chiarelli*, of the Length of 40 *Roman* Palms. Afterwards at 8^h. 44′ the third Satellite appeared to be ſo united with the fourth, that both ſeem'd to be but one Satellite. They were diſtant from the Center of *Jupiter* about $5\frac{1}{2}$ of his Diameters. But at 9^h. 4′ they were again disjoined. The Fourth in an inverſe Situation appear'd ſomething more depreſs'd than the Third, and ſomething more diſtant from *Jupiter*. Therefore it was more Northerly than the Third.

Sept. $\frac{18}{29}$, at 10^h. 36′. 23″, the firſt or the inmoſt Satellite began to emerge from the Shadow, in a Tube of 25 Palms, of Mr. *Campani*.

Nov. $\frac{12}{23}$, at 7^h. 32′. 22″, the firſt Satellite began to emerge, when ſeen thro' a Tube of Mr. *Chiarelli* of 40 Palms. Afterwards the ſame Night at 7^h. 46′ the Firſt and Second are very near, and at 7^h. 53′ the ſame were ſo near, that they could ſcarce be diſtinguiſhed from one little Point.

Dec. 9, *n. ſt.* or *Nov.* 28, old ſt. at 5^h. 45′. 45″, the firſt Satellite began to emerge from the Shadow of *Jupiter*.

Dec. 21, old ſt. at 5^h. 50′. 22″, the firſt Satellite was again ſeen as beginning to emerge out of the Shadow.

N. B. *From theſe Obſervations reduced to an accurate Calculation, it is very plain, that the ſecond Equation, which we ſuppoſe to ariſe from the progreſſive Motion of Light, muſt neceſſarily be admitted. For after 57 Revolutions*

lutions of the inmoſt Satellite, in which Jupiter *has withdrawn from the Earth more than by a* Radius *of the* Orbis Magnus, *the laſt Eclipſe is ſeen almoſt* 9 *Minutes later than it ought, according to the Tenor of the firſt Obſervation: Which agrees with the Hypotheſes of Mr.* Caſſini

From the ſame it is alſo confirm'd, (which we alſo have obſerved before) that the Motion of the inmoſt Satellite of Jupiter *is a little quicker than in the moſt elaborate Tables of Mr.* Caſſini, *communicated to the Publick now* 20 *Years ago. Now that little Error ſeems hardly to exceed two Minutes of Time in each Revolution of* Jupiter, *or in* 12 *Years; by which the Heavens anticipate the Calculation of Mr.* Caſſini. *But when this Correction is taken in, the Agreement will be ſufficiently accurate.*

Tranſit *of the Body and Shade of* Jupiter's *fourth* Satellite *over the* Disk *of the* Planet, *communicated by Mr.* J. Pound, n. 359. p. 900.

XXXIII. On the 16th of *February* 1719, at $6^h\frac{1}{4}$, thro' a ſhort Tube, we ſaw all the 4 Satellites, the 3 outermoſt on the *Eaſt* Side of *Jupiter*, and the innermoſt near the *Weſtern* Limb approaching to an Eclipſe. The Fourth at that Time was about half a Semidiameter of *Jupiter* from the Eaſtern Limb. Then it proved cloudy till about 8^h, at which Time (thro' the *Hugenian* Teleſcope) we could ſee only the ſecond and third Satellites, the firſt being behind *Jupiter* in the Shadow, and the fourth entred upon the Disk. We ſaw at this Time a dark Spot, a little *Northward* of the great *Northern* Zone, and near the *Eaſtern* Limb, where the Satellite was to enter on the Disk; which Spot we took for the Shade of the Satellite. The Clouds then again intercepted our View, till $8^h. 53'$. *Æq. T.* at which Time the firſt Satellite was lately emerged out of the Shadow, and the Spot advanced ſo far, that we perceived it would arrive at the Middle of *Jupiter*, near two Hours ſooner than the Shade ought to have done by our Computation; but not imagining, that this dark Spot could be any Thing elſe but the Shade, we concluded there had been ſome Error in the Calculation, which we thought to re-examine afterwards. On this Preſumption we left off obſerving till $9^h. 35'$. at which Time we were ſurprized to ſee a Notch in the Limb of *Jupiter*, near the Place where the former Spot entred. This laſt Appearance agreeing well with the Time, that the Shade of the Satellite ought to have entred the Disk, ſoon made us alter our former Opinion, and conjecture, that this, and not the other Spot, was the ſaid Shade. At $9^h. 39'\frac{1}{2}$ *Æq. T.* the Notch vaniſhing, a round black Spot appeared within the Limb, but in Contact with it. At $9^h. 45'$. we judged the firſt Spot, and at $11^h. 45'$, the ſecond, to be in the Middle of *Jupiter*.

At $11^h. 50'$. the firſt Spot touched the Limb, being within the Disk; ſoon after which the Limb in that Place ſeemed a little protuberant. At $12^h. 5'$. appeared the fourth Satellite juſt come out of the Disk, and touching the Limb in the Place where the Protuberancy was. At $12^h. 7'$. we could perceive the Satellite ſeparated from the Limb. At $13^h. 56'$. the ſecond black Spot, ſtill within the Disk, juſt touched the *Weſtern* Limb; ſoon after which there appear'd a Notch in this Part of the Limb, as it did on the other at the coming on of this Spot. At $14^h. 6'$. the Spot was all gone off, and the Limb appear'd clear and entire. The firſt Spot, when in the Middle of *Jupiter*, was almoſt as black as the ſecond when near the Limb, but ſomewhat leſs and a little more *Northerly*.

At the Time that the firſt Spot was in the Middle of the Disk, the three innermoſt Satellites appear'd to the *Eaſt* of *Jupiter*; the firſt (as aforeſaid) having lately emerged out of the Shadow; the ſecond being almoſt at its greateſt Diſtance; and the third having paſſed the Axis of the Shade about twelve Hours before, and appearing at this Time about three Diameters of *Jupiter* from his Limb. The Times that theſe Spots arrived at the Middle of the Disk are agreeable to the Times found by Calculation, in which the fourth Satellite and its Shade ought to have appeared there. From all which 'tis very plain, that the firſt of theſe Spots was the fourth Satellite itſelf, and the ſecond its Shadow.

We have ſeen the firſt and ſecond Satellites appearing not as dark Spots, but as bright ones (ſomewhat different from the Light of *Jupiter*) for ſome little Time after they entred his Disk, but as they approached nearer the Middle we loſt Sight of them. And we have frequently obſerved, that the ſame Satellites appear brighter at ſome Times than at others; and that when one of them hath ſhined with its utmoſt Splendour, the Light of another hath been conſiderably diminiſhed. From whence 'tis very probable at leaſt, not only that the Satellites revolve upon their proper Axes, but alſo that ſome Parts of their Surfaces do very faintly (if at all) reflect the Solar Rays to us.

All which hath for ſome Time ſince been obſerved and taken Notice of by Meſſ. *Caſſini* and *Miraldi*, as may be ſeen in the *Memoirs* of the *Academie Royale* for the Years 1707 and 1714.

Tables *for computing the* Eclipſes *of the* firſt Satellite *of* Jupiter, *by Mr.* J. Pound, n. 361. p. 1021.

XXXIV. It being now 26 Years ſince Mr. *Caſſini*'s Tables were publiſhed, Length of Time hath diſcovered, that the Motion of the firſt *Satellite* is a ſmall Matter ſwifter than M. *Caſſini* hath ſuppoſed it; and Mr. *Pound* has of late applied himſelf to rectify by frequent Obſervation what he found amiſs in his *Calculus*; and has put it into a Form more eaſy and compendious, by bringing what M. *Caſſini* had given us in odd Numbers, to the Milleſimals of a Circle, both as to *Numb.* I. which he calls *Numb.* A. being the mean Anomalie of *Jupiter* in ſuch Parts; as alſo to *Numb.* II. or our *Numb.* B. which is the Diſtance of the mean Place of *Jupiter*, from the true Place of the *Sun*, and which, with the Addition of the Equation of *Numb.* B. gives the true Angle of *Commutation* in the ſame Milleſimals of a Circle. And having deducted from the *Epoches* the greateſt Equations both of *Numb.* A. and B. he reſtores them again by adding as much to the Equations themſelves, by which Means they all become affirmative, ſo that the whole Computation is performed by *Addition* only.

* *Vid.* ſupr. V. I. C. IV. §. XCII.

In N° 214. of the *Phil. Tranſ.* * there is an Epitome of M. *Caſſini*'s Tables, where the Method of his *Calculus* is explained at large, for which Reaſon this ſhorter Deſcription may at preſent ſuffice.

Epochs of the Conjunctions of the firſt Satellite with Jupiter.

Current *Julian* Year.	Conjunction. D.	H.	′	″	Num. A.	Num. B.
1719	1	6	11	13	872	396
1720	0	20	22	40	956	810
21	1	5	2	44	40	229
22	0	19	14	11	125	143
23	0	9	25	38	209	57
1724	1	18	5	42	293	971
1725	0	8	17	10	377	889
26	1	16	57	13	462	808
27	1	7	8	41	546	722
28	0	21	20	8	630	636
1729	1	6	0	12	715	554
1730	0	20	11	39	799	468
31	0	10	23	7	883	382
32	0	0	34	34	967	296
33	0	9	14	38	52	215
1734	1	17	54	41	136	133
1735	1	8	6	9	220	47
36	0	22	17	36	305	961
37	1	6	57	40	389	880
38	0	21	9	7	473	794
1739	0	11	20	35	557	708
1740	0	1	32	2	642	622
41	0	10	12	6	726	540
42	0	0	23	33	810	454
43	1	9	3	37	895	373
1744	0	23	15	4	979	287
1745	1	7	55	8	63	205
46	0	22	6	35	148	119
47	0	12	18	3	232	33
48	0	2	29	30	316	947
1749	0	11	9	34	400	866
1749	0	11	9	34	400	866
1750	0	1	21	1	485	780
51	1	10	1	5	569	698
52	1	0	12	33	653	612
53	1	8	52	37	738	531
1754	0	23	4	4	822	445
1755	0	13	15	32	906	359
56	0	3	27	0	990	273
57	0	12	7	3	75	191
58	0	2	18	30	159	110
1759	1	10	58	34	243	24
1760	1	1	10	1	328	938
61	1	9	50	35	412	856
62	1	0	1	2	496	770
63	0	14	13	0	580	684
1764	0	4	24	27	665	598
1765	0	13	4	13	749	517
66	0	3	15	58	833	431
67	1	11	56	2	918	349
68	1	2	7	29	2	263
1769	1	10	47	33	86	182
1770	1	0	59	0	171	96
71	0	15	10	28	257	10
72	0	5	21	56	339	924
73	0	14	2	0	423	842
1774	0	4	13	27	508	761
1775	1	12	53	31	592	675
76	1	3	4	58	676	589
77	1	11	45	1	761	507
78	1	1	56	28	845	421
1779	0	16	7	56	929	335

Revolutions of the firſt Satellite of Jupiter in Months of

January.				N.	Nu.	*March.*				N.	Nu.
D.	h.	′	″	A.	B.	D.	h.	′	″	A.	B.
1	18	28	36	0	5	1	4	12	23	14	155
3	12	57	12	1	9	2	22	40	59	14	159
5	7	25	48	1	14	4	17	9	35	15	164
7	1	54	24	2	18	6	11	38	10	15	168
8	20	23	0	2	23	8	6	6	46	16	173
10	14	51	36	2	27	10	0	35	22	16	177
12	9	20	12	3	32	11	19	3	58	16	182
14	3	48	48	3	37	13	13	32	34	17	186
15	22	17	24	4	41	15	8	1	10	17	190
17	16	46	0	4	46	17	2	29	46	18	195
19	11	14	36	4	51	18	20	58	22	18	199
21	5	43	12	5	55	20	15	36	58	18	204
23	0	11	47	5	60	22	9	55	34	19	208
24	18	40	23	6	64	24	4	24	10	19	213
26	13	8	59	6	69	25	22	52	46	20	217
28	7	37	35	7	73	27	17	21	22	20	221
30	2	6	11	7	78	29	11	49	58	20	225
31	20	34	47	7	82	31	6	18	34	21	230
February.						*April.*					
0	20	34	47	7	82	0	6	8	34	21	230
2	15	3	23	8	87	2	0	47	10	21	235
4	9	31	59	8	92	3	19	15	46	22	239
6	4	0	35	9	96	5	13	44	22	22	244
7	22	29	11	9	101	7	8	12	58	22	248
9	16	57	47	9	105	9	2	41	34	23	252
11	11	26	23	10	110	10	21	10	10	23	257
13	5	54	59	10	114	12	15	38	46	24	261
15	0	23	35	11	118	14	10	7	22	24	265
16	18	52	11	11	123	16	4	35	58	25	270
18	13	20	47	11	128	17	23	4	33	25	274
20	7	49	23	12	132	19	17	33		25	279
22	2	17	59	12	137	21	12	1	45	26	283
23	20	46	35	13	141	23	6	30	21	26	287
25	15	15	11	13	146	25	0	58	57	27	292
27	9	43	47	13	150	26	19	27	33	27	296

April.				N.	Nu.
D.	h.	′	″	A.	B.
28	13	56	9	27	300
30	8	24	45	28	304
May.					
0	8	24	45	28	304
2	2	53	21	28	309
3	21	21	57	29	313
5	15	15	33	29	317
7	10	90	9	29	322
9	4	47	45	30	326
10	23	16	21	30	330
12	17	44	57	31	335
14	12	13	33	31	339
16	6	42	9	31	343
18	1	10	45	32	348
19	19	39	21	32	352
21	14	7	57	33	356
23	8	36	33	33	361
25	3	5	9	33	365
26	21	33	45	34	369
28	16	2	21	34	373
30	10	30	57	35	378
June.					
0	10	30	57	35	378
1	4	59	32	35	382
2	23	28	8	36	386
4	17	56	44	36	391
6	12	25	20	36	395
8	6	53	56	27	399
10	1	22	32	37	403
11	19	51	8	38	408
13	14	19	44	38	412
15	8	48	20	38	416
17	3	16	56	39	420
18	21	45	32	39	425
20	16	14	8	40	429
22	10	42	44	40	433

June.				N.	Nu.
D.	h.	′	″	A.	B.
24	5	11	20	40	438
25	23	39	56	41	442
27	18	8	32	41	446
29	12	37	8	42	450
July.					
1	7	5	44	42	455
3	1	34	20	42	459
4	20	2	56	43	463
6	14	31	32	43	468
8	9	0	8	44	472
10	3	28	44	44	476
11	21	57	20	45	480
13	16	25	55	45	485
15	10	54	31	45	489
17	5	23	7	46	493
18	23	51	43	46	498
20	18	20	19	47	502
22	12	48	55	47	506
24	7	17	31	47	510
26	1	46	7	48	515
27	20	14	43	48	519
28	14	43	19	49	523
31	9	11	55	49	528
Auguſt.					
0	9	11	55	49	528
2	3	40	31	49	532
3	22	9	7	50	536
5	16	37	43	50	541
7	11	6	19	51	545
9	5	34	55	51	549
11	0	3	31	51	554
12	18	32	7	52	558
14	13	0	43	52	562
16	7	29	19	53	567
18	1	57	55	53	571
19	20	26	31	54	575

Revolutions of the firſt Satellite of Jupiter in Months of

Auguſt.				N.	Nu.
D.	h.	′	″	A.	B.
21	14	55	7	54	580
23	9	23	43	54	584
25	3	52	18	55	588
26	22	20	54	55	593
28	16	49	30	56	597
30	11	18	6	56	602
September.					
1	5	46	42	56	606
3	0	15	18	57	610
4	18	43	54	57	615
6	13	12	30	58	619
8	7	41	6	58	624
10	2	9	42	58	628
11	20	38	18	59	632
13	15	6	54	59	637
15	9	35	30	60	641
17	4	4	6	60	646
18	22	32	42	60	650
20	17	1	18	61	655
22	11	29	54	61	659
24	5	58	30	62	663
26	0	27	6	62	668
27	18	55	42	62	672
29	13	24	18	63	677
October.					
1	7	52	54	63	681
3	2	21	30	64	686
4	20	50	6	64	590
6	15	18	41	65	595
8	9	47	17	65	699
10	4	15	53	65	704
11	22	44	29	66	708
13	17	13	5	66	713
15	11	41	41	67	717
17	6	10	17	67	721
19	0	38	53	67	726
20	19	7	29	68	730
22	13	36	5	68	735
24	8	4	41	69	739
26	2	33	17	69	744
27	21	1		69	749
29	15	30	29	70	753

October.				N.	Nu.
D.	h.	′	″	A.	B.
31	9	59	5	79	758
November.					
0	9	59	5	70	758
2	4	27	41	71	762
3	22	56	17	71	767
5	17	24	53	71	772
7	11	53	29	72	776
9	6	22	5	72	781
11	0	50	41	73	785
12	19	19	17	73	790
14	13	47	53	74	794
16	8	16	29	74	799
18	2	42	5	74	804
19	21	13	40	75	808
21	15	42	16	75	813
23	10	10	52	76	817
25	4	39	28	76	822
26	23	8	4	76	827
28	17	36	40	77	831
30	12	5	16	77	836
December.					
0	12	5	16	77	836
2	6	33	52	78	840
4	1	2	28	78	845
5	19	31	4	78	849
7	13	59	40	79	854
9	8	28	16	79	859
11	2	56	52	80	863
13	21	25	28	80	868
14	15	54	4	80	873
16	10	22	40	81	877
18	4	51	16	81	882
19	23	19	52	82	886
21	17	48	28	82	891
23	12	17	4	82	897
25	6	45	40	83	900
27	1	14	16	83	905
28	19	42	52	84	909
30	14	11	28	84	914

First Equations of the Conjunctions of the first Satellite with Jupiter.

Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.
	′	″			′	″			′	″			′	″	
0	39	8	15	128	12	7	26	256	0	1	31	384	11	52	26
4	38	12	16	132	11	27	26	260	0	0	31	388	12	37	26
8	37	16	16	136	10	47	26	264	0	1	31	392	13	23	25
12	36	21	16	140	10	9	27	268	0	3	31	396	14	11	25
16	35	26	17	144	9	31	27	272	0	7	31	400	14	59	25
20	34	30	17	148	8	45	27	276	0	12	31	404	15	48	24
24	33	35	17	152	8	19	27	280	0	19	31	408	16	38	24
28	32	40	18	156	7	44	28	284	0	28	30	412	17	30	24
32	31	45	18	160	7	10	28	288	0	38	30	416	18	22	23
36	30	50	19	164	6	38	28	292	0	50	30	420	19	15	23
40	29	56	19	168	6	7	28	296	1	3	30	424	20	9	23
44	29	3	19	172	5	37	28	300	1	17	30	428	21	4	22
48	28	10	20	176	5	8	29	304	1	33	30	432	22	59	22
52	27	16	20	180	4	41	29	308	1	50	30	436	22	55	22
56	26	23	20	184	4	15	29	312	2	8	30	440	23	53	21
60	25	30	21	188	3	49	29	316	2	28	30	444	24	51	21
64	24	38	21	192	3	24	29	320	2	51	30	448	25	49	21
68	23	47	21	196	3	1	29	324	3	15	29	452	26	48	20
72	22	56	22	200	2	40	30	328	3	40	29	456	27	48	20
76	22	5	22	204	2	20	30	332	4	6	29	460	28	48	19
80	21	15	22	208	2	1	30	336	4	34	29	464	29	49	19
84	20	26	23	212	1	42	30	340	5	3	29	468	30	50	19
88	19	37	23	216	1	25	30	344	5	34	29	472	31	51	18
92	18	48	23	220	1	10	30	348	6	5	28	476	32	53	18
96	18	0	24	224	0	58	30	352	6	38	28	480	33	55	17
100	17	14	24	228	0	47	30	356	7	13	28	484	34	57	17
104	16	28	24	232	0	36	30	360	7	50	28	488	35	59	17
108	15	42	24	236	0	26	30	364	8	27	27	492	37	1	16
112	14	57	25	240	0	18	30	368	9	6	27	496	38	5	16
116	14	11	25	244	0	12	31	372	9	46	27	500	39	8	15
120	13	30	25	248	0	7	31	376	10	27	27	504	40	11	15
124	12	48	26	252	0	4	31	380	11	9	26	508	41	15	14
128	12	7	26	256	0	1	31	384	11	52	26	512	42	17	14

First Equations of the Conjunctions of the first Satellite with Jupiter.

Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æq Nu. B.	Num. A.	Æquat. Conjunct. Adde.		Æ Nu.
	′	″			′	″			′	″			′	″	
512	42	17	14	640	70	26	3	768	77	40	0	896	61	48	6
516	43	19	14	644	71	3	3	772	77	29	0	900	61	2	7
520	44	21	13	648	71	38	3	776	77	18	0	904	60	15	7
524	45	23	13	652	72	11	2	780	77	6	0	908	59	28	7
528	46	25	13	656	72	42	2	784	76	51	1	912	58	39	8
532	47	26	12	660	73	13	2	788	76	34	1	916	57	50	8
536	48	27	12	664	73	42	2	792	76	15	1	920	57	1	8
540	49	28	11	668	74	10	2	796	75	56	1	924	56	11	9
544	50	28	11	672	74	36	1	800	75	36	1	928	55	20	9
548	51	28	11	676	75	1	1	804	75	15	1	932	54	29	9
552	52	27	10	680	75	25	1	808	74	52	1	936	53	38	10
556	53	25	10	684	75	48	1	812	74	27	1	940	52	46	10
560	54	23	9	688	76	8	1	816	74	1	2	944	51	53	10
564	55	21	9	692	76	26	1	820	73	35	2	948	51	0	11
568	56	17	9	696	76	43	0	824	73	8	2	952	50	6	11
572	57	12	8	700	76	59	0	828	72	39	2	956	49	13	11
576	58	7	8	704	77	13	0	832	72	9	2	960	48	20	12
580	59	1	8	708	77	26	0	836	71	38	3	964	47	26	12
584	59	54	7	712	77	38	0	840	71	6	3	968	46	31	12
588	60	46	7	716	77	48	0	844	70	32	3	972	45	36	13
592	61	38	6	720	77	57	0	848	69	57	3	976	44	41	13
596	62	28	6	724	78	4	0	852	69	21	3	980	43	46	13
600	63	17	6	728	78	9	0	856	68	45	4	984	42	50	14
604	64	5	5	732	78	13	0	860	68	7	4	988	41	55	14
608	64	53	5	736	78	15	0	864	67	29	4	992	41	0	14
612	65	39	5	740	78	16	0	868	66	49	4	996	40	4	15
616	66	24	5	744	78	15	0	872	66	9	5	1000	39	8	15
620	67	7	4	748	78	12	0	876	65	28	5	1004	38	12	16
624	67	49	4	752	78	9	0	880	64	46	5	1008	37	16	16
628	68	30	4	756	78	4	0	884	64	3	5	1012	36	21	16
632	69	10	4	760	77	58	0	888	63	19	6	1016	35	26	17
636	69	49	3	764	77	50	0	892	62	34	6	1020	34	30	17
640	70	26	3	768	77	40	0	896	61	48	6	1024	33	35	17

Second Equations of the Conjunctions of the firſt Satellite with Jupiter.

Addendæ.

Num. B. Æqu.	0		100		200		300		400		500		600		700		800		900	
	Æqu.		*Æqu.*		*Æq.*		*Æq.*		*Æq.*		*Æq.*		*Æq.*		*Æq.*		*Æqu.*		*Æqu.*	
	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″
0	14	0	12	52	9	45	5	30	1	37	0	0	1	37	5	30	9	45	12	52
4	14	0	12	46	9	36	5	20	1	30	0	0	1	44	5	40	9	54	12	58
8	13	59	12	40	9	26	5	9	1	23	0	1	1	52	5	51	10	3	13	2
12	13	59	12	35	9	17	4	59	1	16	0	2	1	59	6	1	10	12	13	7
16	13	58	12	29	9	7	4	48	1	9	0	3	2	7	6	11	10	21	13	11
20	13	57	12	23	8	58	4	38	1	3	0	4	2	15	6	22	10	31	13	16
24	13	56	12	17	8	48	4	28	0	57	0	5	2	24	6	33	10	40	13	20
28	13	54	12	11	8	38	4	18	0	52	0	7	2	32	6	44	10	49	13	25
32	13	53	12	4	8	28	4	8	0	46	0	10	2	41	6	55	10	57	13	29
36	13	51	11	56	8	17	3	58	0	40	0	13	2	50	7	5	11	5	13	33
40	13	49	11	49	8	7	3	58	0	35	0	16	2	59	7	16	11	13	13	36
44	13	47	11	42	7	57	3	38	0	31	0	19	3	9	7	26	11	20	13	38
48	13	44	11	34	7	47	3	29	0	27	0	23	3	19	7	36	11	27	13	41
52	13	41	11	27	7	36	3	19	0	23	0	27	3	29	7	47	11	34	13	44
56	13	38	11	20	7	26	3	9	0	19	0	31	3	38	7	57	11	42	13	47
60	13	36	11	13	7	16	2	59	0	16	0	35	3	48	8	7	11	49	13	49
64	13	33	11	5	7	5	2	50	0	13	0	40	3	58	8	17	11	56	13	51
68	13	29	10	57	6	55	2	41	0	10	0	46	4	8	8	28	12	4	13	53
72	13	25	10	49	6	44	2	32	0	7	0	52	4	18	8	38	12	11	13	54
76	13	20	10	40	6	33	2	24	0	5	0	57	4	28	8	48	12	17	13	56
80	13	16	10	31	6	22	2	15	0	4	1	3	4	38	8	58	12	23	13	57
84	13	21	10	21	6	11	2	7	0	3	1	9	4	48	9	7	12	29	13	58
88	13	7	10	12	6	1	1	59	0	2	1	16	4	59	9	17	12	35	13	59
92	13	2	10	3	5	51	1	52	0	1	1	23	5	9	9	26	12	40	13	59
96	12	58	9	54	5	40	1	44	0	0	1	30	5	20	9	36	12	46	14	0
100	12	52	9	45	5	30	1	37	0	0	1	37	5	30	9	45	12	52	14	0

Third Equations to be added.				*Half Durations of the Eclipses of the first Satellite of* Jupiter.															
Nu. A.	*Equations.*		*Nu.* A.	*Nu.* A.	*Half Durations.*			*Nu.* A.	*Half Durations.*			*Nu.* A.	*Half Durations.*			*Nu.* A.	*Half Durations.*		
	′	″			h.	′	″		h.	′	″		h.	′	″		h.	′	″
0	3	30	1000	0	1	5	9	250	1	7	0	500	1	5	9	750	1	7	46
20	3	29	980	10	1	4	56	260	1	7	15	510	1	4	53	760	1	7	57
40	3	28	960	20	1	4	44	270	1	7	31	520	1	4	39	770	1	8	7
60	3	25	940	30	1	4	33	280	1	7	45	530	1	4	26	780	1	8	15
80	3	19	920	40	1	4	23	290	1	7	57	540	1	4	15	790	1	8	22
100	3	12	900	50	1	4	13	300	1	8	7	550	1	4	7	800	1	8	26
120	3	4	880	60	1	4	7	310	1	8	15	560	1	4	3	810	1	8	28
140	2	56	860	70	1	4	4	320	1	8	22	570	1	4	1	820	1	8	30
160	2	46	840	80	1	4	2	330	1	8	27	580	1	4	0	830	1	8	28
180	2	34	820	90	1	4	0	340	1	8	28	590	1	4	3	840	1	8	26
200	2	22	800	100	1	4	2	350	1	8	29	600	1	4	7	850	1	8	22
220	2	10	780	110	1	4	3	360	1	8	27	610	1	4	13	860	1	8	16
240	1	57	760	120	1	4	6	370	1	8	24	620	1	4	23	870	1	8	8
260	1	44	740	130	1	4	12	380	1	8	17	630	1	4	35	880	1	8	0
280	1	30	720	140	1	4	21	390	1	8	9	640	1	4	49	890	1	7	50
300	1	17	700	150	1	4	31	400	1	7	58	650	1	5	4	900	1	7	37
320	1	5	680	160	1	4	42	410	1	7	46	660	1	5	19	910	1	7	22
340	0	53	660	170	1	4	55	420	1	7	31	670	1	5	36	920	1	7	8
360	0	41	640	180	1	5	9	430	1	7	14	680	1	5	54	930	1	6	55
380	0	31	620	190	1	5	23	440	1	6	58	690	1	6	10	940	1	6	40
400	0	22	600	200	1	5	39	450	1	6	40	700	1	6	28	950	1	6	23
420	0	14	580	210	1	5	55	460	1	6	20	710	1	6	46	960	1	6	8
440	0	8	560	220	1	6	11	470	1	6	2	720	1	7	2	970	1	5	54
460	0	4	540	230	1	6	26	480	1	5	45	730	1	7	17	980	1	5	37
480	0	2	520	240	1	6	43	490	1	5	26	740	1	7	33	990	1	5	22
500	0	0	500	250	1	7	0	500	1	5	9	750	1	7	46	1000	1	5	9

The Uſe *of the* Tables.

The Eclipſes of the *firſt* Satellite of *Jupiter* afford the beſt Means of determining the Longitude of Places on the Land, where Teleſcopes of a convenient Length may be uſed; thirteen of theſe Eclipſes happening every 23 Days; and that the Obſerver may know near the Matter, when theſe Opportunities offer themſelves, he may readily compute the Times of the Immerſions or Emerſions of this Satellite with great Exactneſs, by following very ſhort Precepts, which admit of no Exception or Caution, *viz.*

Out of the firſt Table take the *Epoche* for the Year, with its correſponding *Numb.* A and *Numb.* B; and to them add out of the Tables of Months, the Day, Hour, Minute and Second, neareſt leſs than the Time of the Eclipſe you ſeek for, together with its *Numb.* A and B; the Sum of the Times is the mean Time of the Middle of the Eclipſe. 2. With *Numb.* A thus collected take out the firſt Equation of the Conjunctions; as alſo the Æquation of *Numb.* B always to be added to *Numb.* B before found. 3. With *Numb.* B ſo equated, take out the ſecond Æquation of the Conjunctions; and in the laſt Table, the third Æquation, as alſo the Semi-duration of the Eclipſe anſwering to *Numb.* A. 4. To the mean Time of the Middle of the Eclipſe, add all thoſe three Æquations; the Sum ſhall be the true equated Time of the Middle of the Eclipſe ſought. 5. If *Numb.* B equated be leſs than 500, ſubtract the Semiduration, and you will have the Time of the Immerſion, or if it be more than 500, adding the ſame, it will give the Time of the Emerſion.

But Note, the Times thus found are equal Time, ſtill to be reduced to the Apparent: And that in the *Biſſextile* Year, after *February*, one Day is to be deducted from the Day of the Month.

Let it be required to find the Time of the *Immerſion* of this Satellite into *Jupiter*'s Shadow, *November* the 9*th* 1719, in the Morning. The Work ſtands thus,

	D.	h.	′	″	Nu. A.	Nu. B.	
1719.	1	6	11	13	872	396	
Novem.	7	11	53	29	72	776	
Conj. Med.	8	18	4	42	944	172	
Æquat. I.			51	53		10	Æq. B.
Æquat. II.			10	26			
Æquat. III.			3	26		182	B. Æquat.
	8	19	10	27			
		1	6	33	*Semidur. Subſt.*		
Novem.	8	18	3	54			

So that by this *Calculus*, on the 9*th* of *November*, at four Minutes after Six in the Morning, equal Time, may be ſeen the *Immerſion* of this Satellite into *Jupiter*'s Shadow.

Another Example ſhall be of the *Emerſion* on the 5*th* of *April* 1720, *viz.*

	D.	h.	′	″		Nu. A.	Nu. B.	
1720,	0	20	22	40		956	310	
April	4	13	44	22	Biſs.	22	244	
Conj. Med.	5	10	07	02		978	554	
Æquat. I.			44	13			13	Æq. B.
Equat. II.			0	45				
Æquat. III.			3	29			567	B. Æquat.
		1	5	40	*Semidur. Add.*			
April	5	12	01	09				

Hence it appears, that at one Minute after Midnight following the 5th of *April*, equal Time, will happen the Emerſion required.

It may not be amiſs to inform the Reader, that we have learnt, by the Experience of many Years Obſervation, that the ſecond Inequality of this Satellite proceeds from the progreſſive Propagation of Light, and is common to all the reſt of the Satellites: Light being found to proceed, in about ſeven Minutes of Time, as far as from the Sun to the Earth, whether with an equable Motion or otherwiſe is ſtill a Queſtion. For this Reaſon we have added a *third Equation*, whereby to account for the greater Diſtance of *Jupiter* from the *Earth* in *Aphelio* than in *Perihelio*, as the *ſecond Æquation* anſwers to the greater Diſtance of the Planet, when near the Conjunction of the Sun, than when near his Oppoſition.

Obſervations *on ſome of the primary* Planets; *and the* Occultation *of* a fixt Star, *by* Jupiter; *by Mr.* J. Pound, n. 350. p. 506.

XXXV. The Reverend Dr. *Pound*, ſecond to none in Art or Induſtry, has offered the following Obſervations to be communicated to the Publick, made by him at *Wanſtead* with great Accuracy, with very long Tubes and a Micrometer.

Anno 1715, *Aug.* 21, 8^{h}. 25′½ equal Time, *Mars* preceded in Right Aſcenſion the middle Star in the Forehead of *Scorpio* (*Bayer* δ) by 6′. 54″, being more to the North than the Star by 9′. 47″.

Sept. 18, 7^{h}. 30′, *Mars* preceded the bright Star in the Foot of *Serpentarius*, (*Bayer* θ) by 17′. 48″, and had the ſame Declination exactly.

November 30, 18^{h}. 8′, *Saturn* preceded γ, or the Second in the Wing of *Virgo*, by 23′. 19″, and was more South than the fixt Star by 25′. 3″. But *December* 4, 17^{h}. 25′. it preceded it by 10′. 50″, and was more South by 29′. 00″.

Anno 1716, *Feb.* 22, 7^{h}. 23′, equal Time, *Mars* preceded ζ in *Piſces*, or the ſubſequent of the three bright Stars in the Southern String of *Piſces*, by 3′. 25″, and was more to the South than the ſame by 1′. 23″, which therefore he ought to cover before two Hours, perhaps corporally.

June 22, 8^h. 52′, equal Time, *Venus* follow'd the *Lion's Heart* at 34′. 50″, and was more South than the fixt Star by 7′. 23″.

Aug. 14, 15^h. 0′, *Jupiter* preceded *Propus* by only one Minute, with Northern Declination leſs than 14′. 26″.

Aug. 19, 13^h. 2′, *Jupiter* preceded the Teleſcopic fixt Star which is call'd *b*, by 50′. 08″, having the ſame Declination exactly.

Aug. 24, 12^h. 19′, *Jupiter* in the Micrometer was diſtant from the aforeſaid *b*, 5′. 54″, and at the ſame Time from another brighter fixt Star *a*, 7′. 17″. The Diſtance of the fixt Stars was 12′. 31″. Then the leſſer Diameter of *Jupiter* was 0′. 38″.

Sept. 12, 17^h. 0′, *Venus* newly come from her ſecond Station follow'd a Teleſcopic Star at 17′. 40″, and was more Southerly than it by 5′. 30″. This fixt Star was then in ♌, 27°. 44′ ½, with South Latitude 5°. 39′.

Octob. 15, 17^h. 12′ ½, *Venus* in the Micrometer was diſtant 27′. 55″, from a fixt Star *r* in the Leg of the *Lion*.

Nov. 20, 6^h. 18′ ½, *Jupiter* went back to the Stars *a* and *b*, at which he was obſerv'd *Aug*. 24, and was diſtant from *b* 6′. 21″, from *a* 11′. 36″.

Nov. 21, 7^h. 38′, *Jupiter* was diſtant from *b* 9′. 19″, and from *a* 3′. 48″. The Stars were diſtant from one another 12′. 30″. *Jupiter*'s Axis or leſſer Diameter was 0′. 44″. Afterwards at 18^h. 50′. the Star *a* ſeem'd to adhere as it were to *Jupiter*'s Limb, and was about ⅔ of his Semidiameter, or 0′. 15″, more to the North than the Center of *Jupiter*. Now according to theſe Obſervations it appears, that the Middle of the Occultation of the fixt Star, by the Body of *Jupiter* interpoſing, happen'd *Nov*. 21, 19h. 55″, very nearly. Afterwards

Nov. 30.	5^h. 41′	♃ preceded *Propus*	12′. 36″	more Southerly	7′. 36″
Dec. 4.	6. 0	♃ follow'd it	—— 22. 49	——————	7. 47
Dec. 5.	6. 0	Repeated	—— 31. 35	——————	7. 50
Dec. 6.	6. 0	Again	—— 40. 30	——————	7. 52
Dec. 7.	6. 0	Again	—— 49. 15	——————	7. 54

From theſe laſt Obſervations it appears, that *Jupiter* and *Propus* had the ſame Longitude *Dec*. 1, 15^h. 29′, at what Time *Jupiter* was more to the South than the Star by 7′. 40″. From the ſame it will alſo appear, that *Jupiter* was in Oppoſition to the Sun, as to Right Aſcenſion, *Dec*. 6, 12^h. 46′; but as to Longitude *Dec*. 6, 12^h. 34′ ½.

N. B. Thoſe Teleſcopic Stars, call'd *a* and *b*, are had in Mr. *Flamſteed*'s *Britiſh* Catalogue of the fixt Stars, wherein, at the Beginning of the Year 1690, the Place aſſign'd to *a* is ♊ 27°. 54′. 29″, with South Latitude 0°. 21′. 55″. The Place of the other *b* is ♊ 28°. 5′. 24″, with South Latitude 28′. 5″. Neither do we know any other fixt Star hid by the Body of *Jupiter*, and obſerved ſince the Invention of the Teleſcope, except the aforeſaid Star *a*; to which heretofore *Jupiter* apply'd himſelf very cloſely 83 Years ago, *Dec*. 9, ſt. n. in the Year 1633, in the Evening. Then at *Dinia*, *Gaſſendus* ſaw *Jupiter* in Conjunction with this fixt Star, and not above five Semidiameters of his Body above it. Whence a Calculation being duly made, it will appear that the Nodes of this Planet, and the Plain of its Orbit, keep their Situation immoveable in the Sphere of fixt Stars, or at leaſt are moved with a very ſlow Motion. See *Gaſſendus's* Obſervations, Tom. IV. p. 162.

Rectification *of the* Motions *of the five* Satellites *of* Saturn; *with* Obſervations *by Mr.* J. Pound, n. 355. p. 768.

XXXVI. M. *Caſſini* above 30 Years communicated to the World his Diſcovery of the two new *Satellites* of *Saturn*, which made their Number Five. Much about the ſame Time Mr. *Huygens* made the Society a Preſent of the Glaſſes of a *Teleſcope* of 125 Foot Length, with the *Apparatus* for uſing them without a Tube; by Help whereof we might have ſatisfied ourſelves of the Reality of theſe Diſcoveries. But thoſe here, that firſt tried to make uſe of this Glaſs, finding, for want of Practice, ſome Difficulcies in the Management thereof, were the Occaſion of its being laid aſide for ſome Time.

In the mean Time the *French* Aſtronomers, giving us in their yearly *Memoirs* no Obſervations of theſe *Satellites* till very lately, nor having ſeem'd willing to ſhew them in their Glaſſes to ſuch as requeſted it, occaſioned in ſome Perſons a Suſpicion of the Reality of this Diſcovery: And Mr. *Derham* having borrowed of the Society their long Glaſs, could not thereby aſſure himſelf, that the ſmall Stars he ſometimes found about *Saturn*, were really his Satellites, their Situation not agreeing with their Places derived from the Tables of their Motions exhibited in N° 187. * of *Phil. Tranſact.* beſides that he wanted a ſufficient Height to raiſe the Object Glaſs, ſo as to view *Saturn* to Advantage, above the Vapour of the Horizon. But in the *Memoirs* for 1714, M. *Caſſini*, the worthy Succeſſor of his great Father, has given us ſome Obſervations, which clear up the Point, and by ſhewing the Errors of thoſe firſt Tables, has enabled us to be aſſured, that we have ſeen the whole *Satellitium* of *Saturn* ourſelves.

* *Vid.* Supr. V. I. C. IV. S. LXXXII.

The Subſtance of theſe Obſervations is as follows:

Anno 1714, *May* 6, *St. N.* about Mid-night, *Saturn* being then Stationary in ♍ 4°. 27′, the fifth and outermoſt Satellite was in its ſuperior Conjunction with the Planet, and at the ſame Time, the Earth was nearly in the Plain of this Satellite's Orbit, ſo that it appeared to paſs very near the Center of *Saturn*: From hence, and from ſome other preceding Obſervations, M. *Caſſini* concludes, that the Nodes of this Satellite's Orb are in four Degrees of ♍ and ♓, and that its Inclination to the Ecliptick is not much more than half that of the other Satellites. Hence it ſhould follow that the Ellipſes it deſcribes by its apparent Motion about *Saturn*, when in ♊ and ♐ are much flatter and nearer to his Body, than thoſe of the other four, which he allows to move in the Plain of the *Ring*, and to have their Nodes in 21 gr. of ♍ and ♓, with an Inclination to the Ecliptick of 31 Degrees. To confirm this Diſcovery, he produces another Obſervation of his Father's, ther's, near thirty Years before, *viz.* that *Anno* 1685, *May* 31, *St. N.* about Noon, the ſame Satellite was obſerved in ſuperiour Conjunction with *Saturn*, with leſs than one Diameter of the Ring *North* Latitude, *Saturn* being then in ♍ 11°. 48′. So that the Satellite wanted but 7°. 21′ of completing 134 Revolutions, in the Interval of Time between them. From theſe *Data* it was eaſy to ſettle the Theory of this Satellite.

As to the *Fourth*, or the *Hugenian* Satellite; in the *Memoirs* for 1715, we find a very curious Obſervation of it, and the firſt of its Kind, *viz.* that *Mart.* 25°. *S. N.* about 11^{h}. *P. M.* this fourth Satellite, then in *Apogeo*, did immerge behind the Body of *Saturn*. With this Emendation the Place of this Satellite may for the future be computed with a ſufficient Exactneſs.

The third Satellite, by an original Miſtake in the Letters in N°. 187, * is all wrong; its daily Motion being there printed 2^{s}. 18°. 41′. 50″ inſtead of 2^{s}. 19°. 41′. 50″; as may be perceived by the Period thereof being determined in the aforeſaid *Memoirs* of 1714, to be 4^{d}. 19^{h}. 25′. 12″. that is, that it makes 400 Revolutions in 1807 Days. This Satellite was obſerved by M. *Caſſini*, *April* 4^{to} *St. N.* 10^{h}. *P. M.* to have newly paſt its inferior Conjunction with *Saturn*, and a Perpendicular from it fell on the Extremity of the Weſtern *Anſe*, ſo that at about 5^{h}. *P. M.* it was with the Center of the Planet then in ♍. 5°. 23′. and conſequently in ♓ 5°. 23′. But at the Beginning of the *Gregorian* Year 1686, the *Epoche* thereof was ♍ 9°. 39′. So that from the Noon of the laſt of *December* 1685, to *April* 4°. 6^{h}. 18′. *anno* 1714, that is, in 10320 Days 6^{h}. 18′, there have been made $2284\frac{1}{2}$ Revolutions of this Satellite to the Equinoctial; from which *Data*, the Tables of its Motion are readily derivable.

The Radix of the Penintime or ſecond Satellite, according to the aforeſaid Letter, at the Beginning of the *Gregorian* Year 1686, was in ♍ 9°. 10′. But by the Obſervations of M. *Caſſini* made the Nights before and after, this Satellite was in its ſuperior Conjunction *anno* 1714, *April* 4^{d}. $21'\frac{1}{2}$. *St. N.* that is, in ♍ 5°. 21′, where *Saturn* then was: So that *April* 4^{d}. 22^{h}. 12′, an entire Number of Revolutions were performed ſince the *Epoche* of 1686, that is, in 10320 Days 22^{h}. 12′: Which Number can be no other than 3771, according to the Period thereof given in this *Memoire*, *viz.* 2^{d}. 17^{h}. 41′. 22″.

Laſtly, The innermoſt or firſt Satellite, at the ſame Time, *viz.* 1714, *April* 4°. 21^{h}. 30′. *St. N.* was in its inferior Conjunction *proxime*, and conſequently in ♓ 5°. 21′. But the *Epoche* thereof for 1686, is ♑. 24°. 50′. which Place the Satellite had paſt 40 gr. 31′ at the Time of the Obſervation. This Arch it moves in 5^{h}. 6′: Wherefore from the Time of the *Epoche* to *April* 4^{d}. 16^{h}. 24′, 1714, or in 10320 Days 16^{h}. 24′: the Satellite has performed 5467 Revolutions, its Period being determined to be 1 Day, 21 Hours, 18′. 27″, in this *Memoire*.

---

* *Vid.* Supra, V. I. C. IV. S. LXXXII.

Having by the Help of theſe late Obſervations corrected the Motions of the Satellites, and having fixed their *Epoches* for the preſent Year, we were enabled to know where to expect them with more Certainty, and to diſtinguiſh them one from another, and from the ſmall fixt Stars appearing with them. And Mr. *J. Pound* having, by Means of his Steeple of *Wanſted*, provided a *Gnomon* high enough for the Purpoſe, and having fitted a very commodious *Apparatus* for uſing the *Society's* aforeſaid long Teleſcope, ſoon diſcovered by it all theſe five Satellites; and lately communicated to them the following Obſervations.

1718. *April* 21^{d}. 10^{h}. $40'$. The third and fourth Satellites of *Saturn* were in *Apogæo*, a little paſt their Conjunction with *Saturn*: A Perpendicular from the fourth to the tranſverſe *Axis* of the Ring (or Line of the *Anſæ*) fell a little without the Eaſtern *Anſa*; and a Line through the
Fig. 132. fourth and third touched the Eaſtern Limb of *Saturn*, *Fig*. 132.

The firſt was Northward of the Line of the *Anſæ* (and therefore in the *Apogæon* Semicircle alſo) diſtant from the ſaid Line about as far as the End of the conjugate Axis of the Ring was from the Center of ♄, *viz*. nearly $\frac{3}{4}$ of *Saturn's* Semidiameter; and it was about a Semidiameter of the Ring from the Weſtern *Anſa*.

The ſecond was a very little Southward of the Line of the *Anſæ* (and therefore in the *Perigæon* Semicircle) above a Semidiameter of the Ring + the Semidiameter of ♄) from the Weſtern *Anſa*. And the third, firſt and ſecond were in a ſtrait Line.

At 10^{h}. $50'$. A Perpendicular from the third to the Line of the *Anſæ* fell almoſt on the Middle of the bright Part of the Eaſtern *Anſa*, but ſomewhat nearer the Center than the ſaid Middle.

April 22^{d}. 11^{h}. $5'$. The four innermoſt Satellites were all Eaſtward of ♄. The 2^{d} and 4^{th} in the *Apogæon*, and the 1^{st} and 3^{d} in the *Perigæon* Semicircle. A Line thro' the 2^{d} and 4^{th} touched the *South-Eaſt* Limb of ♄. A Line paſſing through the 3^{d} and the End of the conjugate *Axis* of the Ring, was parallel to the Line of the *Anſæ*.

At 11^{h}. $10'$. A Perpendicular from the firſt to the Line of the *Anſæ*,
Fig. 133. fell on the Eaſtern Extremity of the Ring, *Fig*. 133.

Theſe Diſtances and Directions were taken only by Eſtimation, and not by any actual Meaſurement.

The fifth (or outermoſt) Satellite being at this Time near its greateſt Elongation Eaſtward, among ſeveral very ſmall Teleſcopick Stars, he could not determine its Poſition. But by obſerving the Motion of this ſome other Nights before, he was now fully ſatisfied, from the Motions rectified as above, that there are five Satellites of *Saturn*, as M. *Caſſini* had long ſince aſſerted.

In the bright Part of each *Anſa* was a darkiſh Ellipſe nearer to the Outſide than the Inſide of the Ring, as if it was compoſed of two Rings near to one another.

On the Body of ♄, beſide the Ring on the *South*-ſide, there appeared on the *North*-ſide a Zone not ſo far from the Center as the Ring, and not much unlike the ſmalleſt of *Jupiter*'s Belts. Which Appearances were firſt taken Notice of by M. *Caſſini*, in *Phil. Tranſ.* * N° 128. *Vide Fig.* 134.

* *Vid.* ſupra. V.I. C.IV. S. LXXVI, 14.

Fig. 134.

It is not to be expected that theſe Satellites, exceedingly minute in themſelves, and ſo faintly illuminated, ſhould appear when the Air is but ordinarily ſerene, they requiring not only the *Medium* to be *ſummo modo* defecate and limpid, but withal in perfect Darkneſs. For which Reaſons it may well be underſtood why the Gentlemen of the *Pariſian* Obſervatory may have ſometimes made a Difficulty to undertake to ſhew them upon Demand.

XXXVII. By Help of the late Obſervations, and making ſome Correction in the Motions, we owe the whole Syſtem of *Saturn*'s Satellites to Mr. *Huygens*'s Teleſcope: And taking in the accurate Obſervations of the Reverend Dr. *James Pound*, we have obtain'd the following Tables, which very well agree with the Heavens. That is, by adding 2°. 9′ to the Motion of the Inmoſt, and 3°. 25′ to that of the Inmoſt but one, retaining the *Epochs* of M. *Caſſini* to the Year 1686. Alſo increaſing the annual Motion of the Outmoſt by 9′, and taking away 16° from the *Epoch*, which in the Epiſtle N° 187, was faultily wrote ♓ 16°. 19′ for ♓ 0°. 16′, we found that of *Huygens* to be yearly 6′ ſlower. But we have been obliged intirely to reform the Tables of the Third, yet ſtill retaining the *Epoch*, becauſe the daily Motion deliver'd in that Epiſtle was utterly falſe.

Correct Tables *of the* Motions *of* Saturn's *five* Satellites, *by* —— n. 356. p. 776. *Vid.* Supr. V.I. C.IV. S. LXXXII.

A Table of the mean Motions of the innoſt of Saturn's *Satellites, diſcover'd by M.* Caſſini, *An.* 1686.

Years of Chriſt begin-ning.	*Epochs.*			*In Years.*	*Mean Motion.*			*In Days.*	*Mean Motion.*			*H M*	*Mean Motion.* Sex. ° '			*Min.*	*Mean Motion.*	
	s	'	"		s	°	"		s	°	"		°	'	"		°	'
1681	♒	8	48	1	4	4	43	1	6	10	42	1	0	7	57	31	4	6
1686	♉	13	4	2	8	9	25	2	0	21	24	2	0	15	53	32	4	14
1701	♍	6	34	3	0	14	8	3	7	2	6	3	0	23	50	33	4	22
1714	♎	9	57	4	10	29	33	4	1	12	47	4	0	31	47	34	4	30
1715	♒	14	39	5	3	4	16	5	7	23	29	5	0	39	44	35	4	38
1716	♊	19	22	6	7	8	59	6	2	4	11	6	0	47	40	36	4	46
1717	♉	4	47	7	11	13	42	7	8	14	53	7	0	55	37	37	4	54
1718	♍	9	30	8	9	29	6	8	2	25	35	8	1	3	34	38	5	2
1719	♑	14	13	9	2	3	49	9	9	6	17	9	1	11	31	39	5	10
1720	♉	18	55	10	6	8	32	10	3	16	59	10	1	19	28	40	5	18
Months of the Com. Year.	*Mean Motion.*			11	10	13	15	11	9	27	41	11	1	27	24	41	5	26
	s	°	"	12	8	28	40	12	4	8	22	12	1	35	21	42	5	34
				13	1	3	23	13	10	19	4	13	1	43	18	43	5	42
Jan.	0	0	0	14	5	8	5	14	4	29	46	14	1	51	15	44	5	50
Febr.	5	1	38	15	9	12	48	15	11	10	28	15	1	59	11	45	5	58
Mar.	3	1	10	16	7	28	13	16	5	21	10	16	2	7	8	46	6	5
Apr.	8	2	48	17	0	2	56	17	0	1	52	17	2	15	5	47	6	13
May	6	23	44	18	4	7	39	18	6	12	34	18	2	23	1	48	6	21
June	11	25	22	19	8	12	21	19	0	23	16	19	2	30	58	49	6	29
July	10	16	19	20	6	27	46	20	7	3	57	20	2	38	55	50	6	37
Aug.	3	17	57	40	1	25	32	21	1	14	39	21	2	46	52	51	6	45
Sept.	8	19	35	60	8	23	19	22	7	25	21	22	2	54	49	52	6	53
Octob	7	10	31	80	3	21	5	23	2	6	3	23	3	2	45	53	7	1
Nov.	0	12	9	100	10	18	51	24	8	16	45	24	3	10	42	54	7	9
Dec.	11	3	5	120	5	15	37	25	2	27	27	25	3	18	39	55	7	17
In Leap-Year after February add the Motion of one Day.								26	9	8	9	26	3	26	35	56	7	25
								27	3	18	50	27	3	34	32	57	7	33
								28	9	29	32	28	3	42	28	58	7	41
								29	4	10	14	29	3	50	25	59	7	46
								30	10	20	56	30	3	58	22	60	7	57

A Tabl

A Table of the Mean Motions of the Inmoſt but one of the Satellites of Saturn, *diſcover'd by M.* Caſſini, *Anno* 1686.

Years of Jul. beginning.	*Epochs.* s	°	′	*In Years.*	*Mean Motion.* s	°	′	*In Days.*	*Mean Motion.* s	°	″	*H M*	*Mean Motion.* Sex. ° °	′ ′	″	*Min.*	*Mean Motion.* ′	″
1681	♓	3	23	1	4	10	2	1	4	11	32	1	0	5	29	31	2	50
1686	♉	5	25	2	8	20	4	2	8	23	4	2	0	10	58	32	2	56
1701	♓	22	3	3	1	0	6	3	1	4	36	3	0	16	26	33	3	1
1714	♑	7	5	4	9	21	40	4	5	16	8	4	0	21	55	34	3	7
1715	♉	17	7	5	2	1	42	5	9	27	40	5	0	27	24	35	3	12
1716	♍	27	9	6	6	11	44	6	2	9	12	6	0	32	53	36	3	17
1717	♊	18	43	7	10	21	46	7	6	20	44	7	0	38	22	37	3	23
1718	♎	28	45	8	7	13	20	8	11	2	16	8	0	43	51	38	3	28
1719	♓	8	47	9	11	23	22	9	3	13	49	9	0	49	19	39	3	34
1720	♋	18	49	10	4	3	24	10	7	25	21	10	0	54	48	40	3	40
Months of the Com. Year.	*Mean Motion.* s	°	′	11	8	13	26	11	0	6	53	11	1	0	17	41	3	45
				12	5	5	0	12	4	18	25	12	1	5	46	42	3	51
				13	9	15	2	13	8	29	57	13	1	11	15	43	3	56
Jan.	0	0	0	14	1	25	4	14	1	11	29	14	1	16	44	44	4	1
Febr.	3	27	34	15	6	5	6	15	5	23	1	15	1	22	13	45	4	7
Mar.	6	20	32	16	2	26	40	16	10	4	33	16	1	27	42	46	4	12
Apr.	10	18	6	17	7	6	42	17	2	16	5	17	1	33	11	47	4	17
May	10	4	7	18	11	16	44	18	6	27	37	18	1	38	39	48	4	23
June	2	1	41	19	3	26	46	19	11	9	9	19	1	44	8	49	4	28
July	1	17	43	20	0	18	20	20	3	20	41	20	1	49	37	50	4	34
Aug.	5	15	17	40	1	6	40	21	8	2	13	21	1	55	6	51	4	39
Sept.	9	12	51	60	1	25	0	22	0	13	45	22	2	0	35	52	4	45
Oct.	8	28	53	80	2	13	20	23	4	25	17	23	2	6	4	53	4	50
Nov.	0	26	27	100	3	1	4	24	9	6	49	24	2	11	32	54	4	56
Dec.	0	12	28	120	3	20	0	25	1	18	22	25	2	17	1	55	5	1
In Leap-Year after February add the Motion of one Day.								26	5	29	54	26	2	22	30	56	5	7
								27	10	11	26	27	2	27	59	57	5	12
								28	2	22	58	28	2	33	27	58	5	18
								29	7	4	30	29	2	38	56	59	5	23
								30	11	16	2	30	2	44	25	60	5	29

A Table of the Mean Motion of the Middlemoſt of Saturn's Satellites, diſcover'd by M. Caſſini, *Anno* 1671.

Years of Jul. beginning.	*Epochs.* s	°	'	*In Years.*	*Mean Motion.* s	°	'	*In Days.*	*Mean Motion.* s	°	'	*H*	*Mean Motion.* Sex.	°	'	*M*	*Mean Motion.* '	"
1681	♍	12	16	1	9	17	2	1	2	19	41	1	0	3	19	31	1	43
1686	♏	27	6	2	7	4	3	2	5	9	23	2	0	6	38	32	1	46
1701	♎	1	17	3	4	21	5	3	7	29	4	3	0	9	58	33	1	49
1714	♎	11	43	4	4	27	48	4	10	18	46	4	0	13	17	34	1	53
1715	♋	28	45	5	2	14	50	5	1	8	27	5	0	16	36	35	1	56
1716	♉	15	47	6	0	1	52	6	3	28	9	6	0	19	55	36	2	0
1717	♉	22	30	7	9	18	53	7	6	17	50	7	0	23	15	37	2	3
1718	♓	9	32	8	9	25	36	8	9	7	31	8	0	26	34	38	2	6
1719	♐	26	34	9	7	12	38	9	11	27	13	9	0	29	53	39	2	10
1720	♎	13	35	10	4	29	40	10	2	16	54	10	0	33	12	40	2	13
Months of the Com. Year.	*Mean Motion.*			11	2	16	42	11	5	6	36	11	0	36	31	41	2	16
	s	°	"	12	2	23	25	12	7	26	17	12	0	39	51	42	2	19
				13	0	10	26	13	10	15	59	13	0	43	10	43	2	23
Jan.	0	0	0	14	9	27	28	14	1	5	40	14	0	46	29	44	2	26
Febr.	10	10	24	15	8	14	30	15	3	25	21	15	0	49	48	45	2	29
Mar.	0	21	44	16	7	21	13	16	6	15	3	16	0	53	8	46	2	33
Apr.	11	2	9	17	5	8	15	17	9	4	44	17	0	56	27	47	2	36
May	6	22	51	18	2	25	16	18	11	24	26	18	0	59	46	48	2	39
June	5	3	16	19	0	12	18	19	2	14	7	19	0	3	5	49	2	43
July	0	23	58	20	0	19	1	20	5	3	49	20	1	6	24	50	2	46
Aug.	11	4	23	40	1	8	2	21	7	23	30	21	1	9	44	51	2	49
Sept.	9	14	47	60	1	27	4	22	10	13	11	22	1	13	3	52	2	53
Oct.	5	5	30	80	2	16	5	23	1	2	53	23	1	16	22	53	2	56
Nov.	3	15	54	100	3	5	6	24	3	22	34	24	1	19	41	54	2	59
Dec.	1	6	37	120	3	24	7	25	6	12	16	25	1	23	1	55	3	3
In Leap-Year after February add the Motion of one Day.								26	9	1	57	26	1	26	20	56	3	6
								27	11	21	39	27	1	29	39	57	3	9
								28	2	11	20	28	1	32	58	58	3	13
								29	5	1	1	29	1	36	17	59	3	16
								30	7	20	43	30	1	39	36	60	3	19

A Table of the Mean Motion of the Outmoſt but one of the Satellites of Saturn, *diſcovered by Mr.* Huygens, *Anno* 1655.

Years of Jul. beginning.	Epochs.			In Years.	Mean Motion.			In Days.	Mean Motion.			H M	Mean Motion. ° ′		Min.	Mean Motion.	
	s	°	′		s	°	′		s	°	″		′	″		′	″
1641	♑	2	48	1	10	20	35	1	0	22	35	1	0	56	31	29	10
1661	♓	13	23	2	9	11	10	2	1	15	9	2	1	53	32	30	6
1681	♈	27	58	3	8	1	45	3	2	7	44	3	2	49	33	31	3
1686	♏	3	28	4	7	14	55	4	3	0	18	4	3	46	34	31	59
1701	♊	12	33	5	6	5	30	5	3	22	53	5	4	42	35	32	55
1714	♓	17	53	6	4	26	5	6	4	15	28	6	5	39	36	33	52
1715	♒	8	28	7	3	16	40	7	5	8	2	7	6	35	37	34	48
1716	♐	29	3	8	2	29	50	8	6	0	37	8	7	31	38	35	45
1717	♐	12	13	9	1	20	25	9	6	23	12	9	8	28	39	36	41
1718	♏	2	48	10	0	11	0	10	7	15	46	10	9	24	40	37	38
1719	♍	23	23	11	11	1	35	11	8	8	21	11	10	21	41	38	34
1720	♌	13	58	12	10	14	45	12	9	0	55	12	11	17	42	39	31
1721	♋	27	8	13	9	5	20	13	9	23	30	13	12	14	43	40	27
Months of the Com. Year.	Mean Motion.			14	7	25	55	14	10	16	5	14	13	10	44	41	24
	s	°	′	15	6	16	30	15	11	8	39	15	14	7	45	42	20
Jan.	0	0	0	16	5	29	40	16	0	1	14	16	15	3	46	43	17
Febr.	1	9	54	17	4	20	15	17	0	23	48	17	16	0	47	44	13
Mar.	8	12	2	18	3	10	50	18	1	16	23	18	16	56	48	45	10
Apr.	7	21	55	19	2	1	25	19	2	8	58	19	17	52	49	46	6
May	6	9	14	20	1	14	35	20	3	1	32	20	18	49	50	47	3
June	5	19	7	40	2	29	10	21	3	24	7	21	19	45	51	47	59
July	4	6	26	60	4	13	45	22	4	16	42	22	20	42	52	48	56
Aug.	3	16	18	80	5	28	20	23	5	9	16	23	21	38	53	49	52
Sept.	2	26	12	100	7	12	55	24	6	1	51	24	22	35	54	50	49
Oct.	1	13	30	120	8	27	30	25	6	24	25	25	23	31	55	51	45
Nov.	0	23	34	140	10	12	5	26	7	17	0	26	24	27	56	52	42
Dec.	11	10	42	160	11	26	40	27	8	9	35	27	25	24	57	53	38
								28	9	2	9	28	26	20	58	54	35
In Leap-Year after February *add the Motion of one Day.*								29	9	24	44	29	27	17	59	55	31
								30	10	17	18	30	28	13	60	56	27

A Table of the mean Motion of the outward Satellite of Saturn, *diſcovered by M.* Caſſini, *Anno* 1671.

Years of Jul. begin-ning.	Epochs.			In Years.	Mean Motion.			In Days.	Mean Motion.			H M	Mean Motion.		Min.	Mean Motion.	
	s	°	'		s	°	'		s	°	"		° '	' "		'	"
1681	♈	8	40	1	7	6	32	1	0	4	32	1	0	11	31	5	51
1686	♈	15	50	2	2	13	3	2	0	9	5	2	0	23	32	6	3
1701	♉	11	53	3	9	19	35	3	0	13	37	3	0	34	33	6	14
1714	♓	20	20	4	5	0	35	4	0	18	9	4	0	45	34	6	25
1715	♎	26	52	5	0	7	10	5	0	22	42	5	0	57	35	6	37
1716	♊	3	23	6	7	13	42	6	0	27	14	6	1	8	36	6	48
1717	♑	14	27	7	2	20	13	7	1	1	44	7	1	19	37	7	0
1718	♌	20	58	8	10	1	17	8	1	6	18	8	1	31	38	7	11
1719	♓	27	30	9	5	7	49	9	1	10	51	9	1	42	39	7	22
1720	♏	4	2	10	0	14	20	10	1	15	23	10	1	53	40	7	34
Months of the Com. Year.	Mean Motion.			11	7	20	52	11	1	19	55	11	2	5	41	7	45
	s	°	"	12	3	1	56	12	1	24	28	12	2	16	42	7	56
				13	10	8	27	13	1	29	0	13	2	27	43	8	8
Jan.	0	0	0	14	5	14	59	14	2	3	32	14	2	39	44	8	19
Febr.	4	20	41	15	0	21	30	15	2	8	5	15	2	50	45	8	30
Mar.	8	27	46	16	8	2	34	16	2	12	37	16	3	1	46	8	42
Apr.	1	18	27	17	3	9	6	17	2	17	9	17	3	13	47	8	53
May	6	4	37	18	10	15	37	18	2	21	42	18	3	24	48	9	4
June	10	25	18	19	5	22	9	19	2	26	14	19	3	35	49	9	16
July	3	11	27	20	1	3	13	20	3	0	46	20	3	47	50	9	27
Aug.	8	2	9	40	2	6	26	21	3	5	18	21	3	58	51	9	38
Sept.	0	22	50	60	3	9	38	22	3	9	51	22	4	9	52	9	50
Oct.	5	8	59	80	4	12	51	23	3	14	23	23	4	21	53	10	1
Nov.	9	29	41	100	5	16	4	24	3	18	55	24	4	32	54	10	12
Dec.	2	15	50	120	6	19	17	25	3	23	28	25	4	43	55	10	24
								26	3	28	0	26	4	55	56	10	35
In Leap-Year after February *add the Motion of one Day.*								27	4	2	32	27	5	6	57	10	46
								28	4	7	5	28	5	17	58	10	58
								29	4	11	37	29	5	29	59	11	9
								30	4	16	9	30	5	40	60	11	21

The mean Motion of the Satellites being thus ſettled, their Revolutions very near the Truth will be theſe following.

	D.	h.	′	″
Of the firſt or inmoſt	1	21	18	$26\frac{1}{2}$
Of the ſecond or inmoſt but one	2	17	41	$10\frac{1}{2}$
Of the third or Middlemoſt	4	12	25	10
Of the fourth or that of *Huygens*	15	22	41	28
Of the fifth or outmoſt	79	7	46	00

Now according to the univerſal Law of Nature, at leaſt in this our Syſtem, and which obtains as well in the Motions of *Jupiter*'s Satellites and of the Moon, as in thoſe of the Primary Planets about the Sun; if we ſuppoſe their Centripetal Forces towards *Saturn* to be in a reciprocal duplicate Ratio of their Diſtances, and therefore the Cubes of their Diſtances from the Center to be as the Squares of their Periodical Times: From the given Diſtance and Period of that of *Huygens*, the Diſtances of the others will come out as follows.

		Semidiam. Saturn's Ring.	*Semidiam. Saturn's Body.*
Diſtance of the	Firſt	1.9289	4.3400
	Second	2.4708	5.5593
	Third	3.4508	7.7643
	Fourth	8.0000	18.0000
	Fifth	23.3146	52.4578

And theſe Diſtances very well agree with M. *Caſſini*'s Obſervations. Now the four inmoſt Satellites deſcribe their Orbits nearly in the Plain of *Saturn*'s *Ring*, that is, in a Plain which to Senſe is parallel to the Plain of our Equator, whatever ſome may alledge to the contrary. But as to the Fifth, Mr. *James Caſſini*, Son to the former, and Heir of his Talents, has lately found, that the Situation of its Orbit is ſomething different from the others. See the *Memoirs of the Academy of* Paris, *for the Year* 1714.

XXXVIII. The following Obſervations, of which we have made a Collection, are extremely accurate, the Meaſures being taken with very long Tubes and Micrometers made with unuſual Nicety.

An. 1717, *April* 15. 9ʰ. 49″, equal Time, Dr. *Pound* obſerved at *Wanſtead*, that *Jupiter* was returned to that Star, which *Nov.* 22, 1716, in the Morning, he cover'd with his Body; concerning which ſee *Phil. Tranſ.* n. 350, (or before, p. 319. Now the Center of * *Jupiter* at that Time was diſtant from that Star, (which is the third of *Gemini* in the *Britiſh* Catalogue) 23′. 22″ towards the North; and at the ſame Time from another near it, (which is the fourth in *Gemini* in the ſame Catalogue) 27′. 11″, and the Planet was very nearly joined to this.

A Collection *of* Aſtronomical *Obſervations for* 1717, 1718. *by*——
n. 357. p. 840.
— *of the* Planets.
* *Vid.* ſupra, p. 319.
n. 354. p. 723.

April 25 following, by the ſame Obſerver and Place, at 10ʰ. 3′, equal Time, *Jupiter* was ſeen at four ſmall fixt Stars, going before them all, and at the very Beginning of *Cancer*. The Center of the Planet was diſtant from *e* 13′. 00″, from *b* 11′. 32″, from *f* 19′. 53″, and from *g* 9′. 27″.

The Day after, *April* 26, at 9^{h}. 7′, the Center of *Jupiter* was diſtant from *e* 8′. 35″, from *f* 9′. 0″, from *g* 4′. 5″, and from *h* 13′. 50″. And he had now gone beyond them all, except *f* to which he was going, and which he ought to leave very little below him the next Day.

Almoſt at the ſame Moment, that is, at Nine a-Clock at *London*, the Star *g* was ſeen in the Vertex of an Equicrural Triangle, or almoſt Equilateral, with the Center of *Jupiter* and his third Satellite, then diſtant ſix Diameters of *Jupiter* towards the Weſt; unleſs that the Leggs of the Triangle were ſomething longer than the Baſe. And within a Quarter of an Hour the Angle at the Center of *Jupiter*, which before was greater than that at the Satellite, grew ſenſibly leſs.

But the three Stars *h*, *g*, *e*, are the 10, 11, and 12 of *Gemini* in the *Britiſh* Catalogue, according to which they had at that Time this Situation; *h* in ♋ 0°. 22′. 15″, with Northern Latitude 0°. 11′. 25″. And *g* in ♋ 0°. 28′. 25″, with Northern Latitude 0°. 3′. 40″. Laſtly *e* in ♋ 0°. 29′. 20″. with Lat. 0°. 8′. 5″. Nor. But the fourth *f* is diſtant from the Star *g* 11′. 40″, from *e* 12′. 15″, and laſtly from *h* 20′ 36″, whence its Place is given. From hence it appears, that *Jupiter* had very little North Latitude, not greater than Half a Minute, at leaſt if Credit may be given to the aforementioned Places of the Stars. This may be of Uſe to Poſterity, in determining the Motion of *Jupiter*'s Nodes, if they have any Motion at all.

The ſame Year, *June* 18, at *London*, in the Houſe of the Royal Society, *Saturn* was ſeen very near a Teleſcopic fixt Star, from whence it was diſtant towards the South hardly one Diameter of the Ring, and a Perpendicular let fall from the Star upon the Line of the *Anſæ*, fell upon the Middle of the Eaſtern *Anſa*. This little fixt Star, inſerted in no Catalogue, then was in ♎ 12°. 58′½, with Northern Latitude 2°. 33′, veary nearly; and had a Companion joined with it of equal Magnitude four Minutes diſtant from it towards the Eaſt, but ſomething more Southerly; whence it may eaſily be diſtinguiſhed, and its Places verified at Pleaſure.

The ſame Night at 10^{h}. 30′, *Mars* was ſeen near the Star which precedes 35 of *Scorpio*, from which it was diſtant 7′. 16″. as meaſured by a Tube of 24 Feet; and that in a right Line drawn through the bright Star θ in the Foot of *Ophiuchus*, and the ſaid fixt Star. Now this Star precedes 35 of *Scorpio* 30′. 27″, of Right Aſcenſion, and is more Southerly than it by 2′. 28″. Whence its Place at that Time was *Sagittary* 15°. 24′. 20″. with South Latitude 3°. 59′. 25″. But θ in *Ophiuchus* was then *Sagittary* 17°. 28′. with North Latitude 1°. 47′. 38″. So that *Mars* preceded that Star in Longitude 4′. 58″. and was more Southerly than it by 5′. 30″.

Afterwards, *Sept*. 13, at 8^{h}. 30′. equal Time, *Mars* was ſeen by Dr. *Pound* to precede the bright Star σ in the Shoulder of *Sagittary* 11′. 54″. At 8^{h}. 25′. the Diſtance of the Planet from the Star was 25′. 00″. exactly.

Dec. 5, at 18^{h}. 30′. equal Time, by the Agreement of Obſervations ſeveral Times repeated, Dr. *Pound* found *Saturn* to precede the bright Teleſcopic Star that was near it 27′. 19″. Right Aſcenſion, and that it was more Southerly than the Star 1′. 59″. At the ſame Time *Saturn* preceded κ in the *Virgin*'s *Garment* 1°. 25′. 21″. and was more Southerly than it 4′. 05″.

05″. Hence the Place of *Saturn* was *Libra* 29°. 16′. 21″. Its Northern Latitude was 2°. 22′. 21″. The Teleſcopic Star was then *Libra* 29°. 40′. 56″. Its North Latitude 2°. 33′. 43″.

An. 1718, *Jan.* 7, at 5^{h}. 30′. equal Time, *Venus* was obſerved near two Stars, which are omitted in the *Britiſh* Catalogue. Now the Planet was more to the South than either of the fixt Stars, being diſtant from the preceding 32′. 30″. and from the ſubſequent 17′. 30″. The preceding Star was then in *Piſces*, 14°. 42′. 20″. with South Latitude 40′. 10″. The other ſubſequent Star was in *Piſces* 15°. 21′. 55″. with South Latitude 27′. 15″. as may be collected from Mr. *Flamſteed*'s Obſervations.

Jan. 15, at 8^{h}. 0′. equal Time, *Jupiter* preceded [illegible] in the Breaſt of *Cancer*, 3°. 30′. 50″ Right Aſcenſion, and was more Southerly than the fixt Star 14′. 15″. Hence *Jupiter*'s Place was *Cancer* 28°. 20′. with North Latitude 36′. 45″.

March 11, at 10^{h}. 36′. equal Time, *Saturn* preceded κ in the *Virgin*'s *Garment* 18′. 51″. and was more Southerly than that Star 5′. 23″. Hence the Place of *Saturn* was *Scorpio* 18°. 34′. with North Latitude 2°. 44′. 8″. That is ſuppoſing, according to the *Britiſh* Catalogue, that κ in *Virgo* was ♍ 0°. 34′. 10″. with Latitude 2°. 55′. 40″. The ſame Night at 17^{h}. 00′. at *Weſtminſter* Dr. *Deſaguliers* and Mr. *Gray* obſerved *Saturn* to precede the Star 19′. 00″. with a greater Declination Southerly 4′. 45″.

April 8, at 11^{h}. 30′. at *London*, *Saturn* was lately ſeen Acronych very little more Weſterly than a bright Teleſcopic Star, and more Northerly than the ſame by 5 Minutes. Whence the Place of the fixt Star was *Libra* 28°. 18′. 30″. its North Latitude 2°. 41′. Now a great Circle drawn through this Star and *Saturn* ſeem'd to be directed to a Star of the fifth Magnitude omitted in the *Britiſh* Catalogue, but which according to *Hevelius* is in the Point of the Northern Wing of *Virgo*, whoſe Place he aſſigns *Libr.* 26°. 10′. with North Latitude 14°. 43′.

The ſame Night at 13^{h}. 20′. at *Wanſted*, a Perpendicular let fall from the ſaid Teleſcopic Star upon the Line of *Saturn*'s *Anſæ* preceded the Center of the Planet about one and a half of the Diameters of the Ring; and the Star was diſtant towards the South 4′. 30″. from the *Anis* of the *Anſæ*. Alſo the Extremity of the Eaſtern *Anſa* was found in a right Line between this Star and another joyn'd to it as it were in Longitude, which was then diſtant from *Saturn* 24′. 48″. towards the North. But the Place of the former Star was then *Libra* 28°. 18′. 3″. with North Latitude 2°. 41′. nearly.

Sept. 7. about Noon, there happen'd a very near Conjunction of *Jupiter* and *Venus*, the View of which was obſtructed by the Clouds from our Aſtronomers. But on the 6th Day aforegoing in the Morning, or 5^{d}. 22^{h}. 57′ 30″. equal Time, at *Wanſtead*, *Venus* was diſtant from *Jupiter* 1°. 3′. 28″. to the Weſt. But on 7^{d}. 17^{h}. 21′. *Venus* now to the Eaſt was diſtant from *Jupiter* 43′. 18″. and at 17^{h}. 34′. *Venus* was more Southern than *Jupiter* by the Difference of Declinations 14′. 23″. And at 17^{h}. 39′. the Diſtance of the Planets was taken 44′. 4″. Hence by the Calculation of a very accurate Obſerver, they were in Conjunction *Sept.* 7. 0^{h}. 9′. equal Time; the Center of *Venus* being more South than *Jupiter*'s only 1′. 42″.

Sept. 18, in the Morning, at *Wanſtead*, *Jupiter* was ſeen near *Cor Leonis*, with which he had been in Conjunction the Day before, *Sept.* 17. at 16^{h}. 51′. equal Time. *Jupiter*'s Center was diſtant from *Cor Leonis* 24′. 22″; and at 17^{h}. 6′. 20″. the Difference of Declination was 12′. 43″. Then an Hour after, or at 17^{h}. 54′. the Diſtance became 24′. 44″, and at 18^{h}. 7′. the Difference of Declinations was found 12′. 35″. Hence by Dr. *Pound's* Calculation, on *Sept.* 17, at 18^{h}. 0′. equal Time, the Place of *Jupiter* was *Leo* 26°. 11′. 7″. with 45′. 32″. North Latitude.

— *of the* Moon *and* Eclipſes.

Anno 1717, *Jan.* 12. at *Weſtminſter*, Mr. *Stephen Gray* obſerved an Appulſe of the Moon to four contiguous Stars under the South Horn of *Taurus*, near which the Moon was obſerved *An.* 1683, *March* 23, old Stile, by *Hevelius* and *Flamſtead*. Therefore at 9^{h}. 45′. apparent Time, the Moon being gibbous, was ſeen as in Conjunction with the preceding Star of the four, which is 107 of *Taurus* in the *Britiſh* Catalogue, and which was then more Southern than the Southern Limb of the Moon, by a Minute and half; at 11^{h}. 29′. another which is leſs, and therefore omitted in the Catalogue, was hid a little below the Middle of the obſcure Limb. At 12^{h}. 24′. the third and brighteſt (110 of *Taurus*) almoſt in Conjunction, was diſtant 6′ from the Northern Limb. Laſtly, At 12^{h}. 54′. the laſt of the four (111 of *Taurus*) was higher than the Northern Limb by 3′. 30″. Now the Place of the preceding, or 107 of *Taurus*, by the ſaid Catalogue was then *Gemini* 18°. 12′. with Southern Latitude 5°. 18′. And 110 of *Taurus* was *Gemini* 19°. 26′¼. with South Latitude 4°. 44′. And the Conſequent, or 111 of *Taurus*, was in *Gemini* 19°. 45′. with South Latitude 4°. 48′⅙. The ſecond little Star, as appear'd from other Obſervations, had then its Place in *Gemini* 19°. 17′. and its Latitude nearly 5°. 5′.

The ſame Year, *March* 16, in the Morning, there was a partial Eclipſe of the Moon, not conſpicuous with us, becauſe of the cloudy Weather. But at *Cambridge* in *New England*, Mr. *Robie*, a very skilful Aſtronomer, ſaw the Beginning of the Eclipſe about Nine a-Clock. And the End near *Palus Mæotis*, at 11^{h}. 42′. 30″. exact enough. But *Cambridge* is under the Altitude of the Pole 42°. 25′. more Weſtern than *London*, 71°. or 4^{h}. 44′. as appears from many former Obſervations.

Vid. Infra p. 338.

Sept. 9, in the Evening, at the Houſe of the Royal Society at *London*, ſome obſerved the End of the *Lunar* Eclipſe at 7^{h}. 26′. But the Moon aroſe at the Middle of the Eclipſe, nor had freed herſelf from the Clouds about the Horizon till a little before the End.

Sept. 14, in the Evening, now for the firſt Time, after a long Interval, the Moon returned to eclipſe the *Bull's Eye*. The Sky at *London* was clearer than uſual, ſo that the Moon and the Star were ſeen as it were riſing together in the Horizon. The Immerſion of the Star happen'd at 9^{h}. 6′. 20″, the Moon being not yet 3° high, in the very Middle as it were of the Eaſtern Limb, that is, over-againſt the Northern Part of that little Spot, which *Hevelius* calls the Lake of *Mœris*, and which *Ricciolus* has denoted by his own Name. But it emerged a little below the Middle of the obſcure Limb, at 9^{h}. 58′. 20″, and in the twinkling of an Eye ſhone forth with its whole Brightneſs. Hence alſo is proved, that even this remarkable Star has next to no Diameter.

Sept. 23, in the Evening, there happen'd an Eclipſe of the Sun, that was hardly to be ſeen in any Part of *Europe*. But from our Parts of *America* we have obtain'd two Obſervations of it, one by a Letter from the worthy Mr. *Keith*, Governour of the Province of *Penſylvania*, who at *Philadelphia*, under the Altitude of the Pole 40°. 0'. nearly, ſaw the Eclipſe already begun, (but which was not begun a Minute before,) at 11^{h}. 55'. About the Middle there were about ten Digits. The End was ſeen exactly at 2^{h}. 46'. 35''.

But the other Obſervation of this was made at *Cambridge*, the Univerſity of *New England*, by Mr. *Robie*. The Beginning of the Eclipſe was obſerved there at 0^{h}. 23'. 0''. after Noon. At 1^{h}. 47'. nine Digits were eclipſed. At 3^{h}. 5'. 10''. the Eclipſe ended, the whole Sun being ſeen through a Teleſcope of 24 Feet. Mr. *W. Derham* communicated this from the Letters of this exact Obſerver.

Dec. 5. The Moon paſs'd a little above the *Bull's Eye*. This near Tranſit was obſerved by that Learned Youth Mr. *Ja. Bradley*, M. A. (the Moon being now almoſt at full,) who compared the Star with that remarkable Spot, which *Ricciolus* calls *Tycho*, but *Hevelius*, *Sinai*; and from ſeveral equal Diſtances, taken with the Micrometer before and after, he concluded that the Star approached near to the Center of the ſaid Spot at 11^{h}. 15'. 8''. equal Time, at *Wanſtead*. At 11^{h}. 15'. 42''. the *Bull's Eye* was diſtant from the neareſt and Southern Limb of the Moon 5'. 55''. But the Spot *Tycho* was diſtant from the ſame Limb 4'. 16''. At 11^{h}. 18'. 42''. the Star was in a right Line with the Spots *Tycho* and *Copernicus*, or *Sinai* and *Ætna*; and at 11^{h}. 25'. 27''. equal Time, it was in a right Line with *Tycho* and *Kepler*. Among theſe Obſervations the Moon's Diameter was found 32'. 45''.

Anno 1718, *Jan.* 29, in the Evening, Dr. *Deſaguliers* and Mr. *Gray* at *Weſtminſter*, expected another Occultation of the *Bull's Eye*; but by the Interpoſition of Clouds they could only ſee, that at 5^{h}. 52'. the Star was not yet immerſed; but afterwards the Clouds growing thinner, the Emerſion was concluded to be at 7^{h}. 20', over-againſt *Hevelius*'s Spot called the Promontory of *Aſiatic Sarmatia*.

Feb. 19, in the Morning, the ſame Obſervators in the ſame Place, variouſly ſtruggling with the Clouds, could hardly ſee the Eclipſe of the Sun. Yet at 6^{h}. 59'. two Digits were ſeen to be eclipſed, and after a Minute of Time the Chord between the *Cuſpids* ſeem'd to be equal to the Semidiameter of the Sun.

But at *Wanſtead* Dr. *Pound* obſerved, that at 6^{h}. 54'. 7''. apparent Time, the Chord between the *Cuſpids* was 18'. 30''. At 7^{h}. 17'. 0''. it was 10'. 18''. At 7^{h}. 19'. 30''. the ſame was found to be 8'. 5''. The Eclipſe ended at 7^{h}. 23'. 20''.

Feb. 25, in the Evening, at 6^{h}. 44'. at *Weſtminſter*, the firſt Star of the *Hyades* in the *Bull's Snout*, (γ according to *Bayer*,) was ſeen in a right Line through the *Cuſpids* of the Moon, and therefore nearly in Conjunction. Now its Diſtance from the Southern Limb of the Moon was 5'. 51''. The Diameter of the Moon meaſured with a Micrometer was 31'. 45''.

Feb. 28, at 8^{h}. 36'. apparent Time, alſo at *Weſtminſter*, an Immerſion was ſeen of the Star in the Knee of *Pollux*, (according to *Bayer* λ of *Gemini*,) under the obſcure Limb of the Moon, on that Side which is ſomething more Northerly than the Spot which *Hevelius* calls *Crete.* The Emerſion was not ſeen, becauſe the Sky was not clear enough. But at $9^h. 51'$. the Star was come out, over-againſt the Northern Part of the greater *Caſpian* Iſland.

Aug. 8, The Moon aroſe a little below the *Bull's Eye*, but becauſe of the Clouds, could not be compared with it. But at *Wanſtead*, at $13^h. 2'. 0''$. apparent Time, the preceding Star of the Contiguous ones at ϵ of *Taurus* according to *Bayer*, (or the laſt but one in our catalogue of the *Hyades*, in N. 354. of the *Philoſophical Tranſactions*, mark'd with the Letter *q*,) was ſeen in a right Line through the *Cuſpids* of the Moon, diſtant from the Southern $4'. 36''$. At $13^h. 7'. 15''$. the Star *p* of the ſame Catalogue emerged a little below the Middle of the obſcure Limb. At $13^h. 19'. 4''$. the Conſequent of the ſaid contiguous Stars emerged, as much diſtant from the Southern Horn, as thoſe contiguous Stars were diſtant from one another, that is, 7 Minutes.

Vid. ſupra, p. 300.

Aug. 29, in the Evening, the Moon almoſt in her Apogæ, ſuffer'd almoſt a total and central Eclipſe; but ſhe aroſe after the Eclipſe was begun. The Reverend Dr. *Pound* exhibited very perſpicuous Obſervations of this Eclipſe, in the Order they are here deſcribed.

Obſerv.	Apparent Time.			An *Eclipſe* of the Moon, obſerved at *Wanſtead*, *Aug.* 29, 1718.		
	h	'	"		'	"
1	6	53	38	The Chord between the *Cuſpids*, meaſured with a Micrometer	22	37
2		55	8	The ſame repeated	21	14
3		56	31	Repeated	19	51
4		57	49	Again	18	28
5		59	38	Once more	15	00
6	7	2	41	The total Immerſion into the Shadow		
7	8	36	13	A bright Star omitted in the Catalogues was hid by the Moon, below the *Palus Mareotis* of *Hevelius*	10	2
8	8	48	18	The Moon began to emerge out of the Shadow		
9		51	13	The Limit of the Shadow through the Middle of *Mareotis*; as alſo the Chord between the *Cuſpids*	15	0
10		53	7	The Chord between the *Cuſpids*	18	28
11		54	16	The ſame repeated	19	51
12		54	59	Again	21	14
13	8	56	18	Once more	22	37
14	9	0	48	*Porphyrites* emerged out of the Shadow		
15		8	3	Mount *Sinai* began to emerge		
16		9	17	The Shadow through the Middle of *Sinai*		
17		10	6	All *Sinai* was now out of the Shadow		
18		11	20	The Shadow paſs'd through the Middle of *Ætna*		
19		17	23	Through the Middle of *Corſica*		
20		20	0	Through the Middle of the greater black Lake		
21		27	54	Through the Middle of *Beſbicus*		
22		28	45	The aforeſaid Star now emerged		
23		32	34	*Byzantium* and *Horminius* emerge together		
24		33	58	The Star had the ſame Declination with the Southern *Cuſpid* of the Eclipſe		
25		43	28	The Chord between the *Cuſpids*	18	28
26		47	2	The ſame repeated	15	00
27	9	53	0	The Eclipſe ſeem'd to finiſh		

At 10^h. 30′. the Diameter of the Moon was taken 29′. 45″. Now the Obſervations being compared with one another, where the Chords of the deficient Parts were found to be equal, the Middle of the Eclipſe is diſcover'd.

	Middle.		
	h.	′	″
From the firſt and thirteenth Obſervations	7	54	58
From the ſecond and twelfth	7	55	3
From the third and eleventh	7	55	24
From the fourth and tenth	7	55	28
From the fifth and ninth	7	55	25
From the ſixth and eighth	7	55	29
Of all which the Middle is	7	55	18

Martin Folkes, Eſq; with ſome other Members of the Royal Society, obſerved the ſame Eclipſe with like Diligence at *London* in *Fleet-ſtreet*, with the Inſtruments and an excellent Teleſcope of Mr. *George Graham*, a very skilful Watch-maker; which Obſervations are as follow.

h.	′	″	
6	38	0	The Moon was hardly ſeen through the Smoke and Vapours of the City.
6	54	13	The Chord between the Cuſpids 21′. 17″. or thereabouts.
7	2	0	The total Immerſion into the Shadow.
7	42	15	A pretty bright Star was diſtant from the Eaſtern Limb of the Moon 19′. 21″.
8	35	18	The ſame fixt Star was hid, about 10 Minutes more to the South than the Center of the Moon.
8	45	50	Now, or as ſome thought a Minute later, the Moon began to emerge.
8	49	38	*Palus Mareotis* emerged with its firſt Margin.
8	50	14	The whole *Palus* was without the Shadow.
9	0	5	The Middle of Mount *Porphyrites* emerged.
9	7	39	The firſt Margin of *Sinai* emerged.
9	9	8	Mount *Sinai* was quite without the Shadow.
9	10	35	The Shadow paſs'd through the Middle of *Ætna*.
9	12	0	All Mount *Ætna* was without the Shadow.
9	18	51	The Shadow paſs'd through the Middle of the *Greater Black Lake*.
9	27	35	The Iſland *Besbicus* wholly emerged.
9	42	21	The Chord between the Cuſpids was 19′. 9″.
9	51	25	The End of the Eclipſe as was judged by ſome.
9	52	45	The End concluded from the foregoing Diſtance of the Cuſpids.
9	56	45	The Diameter of the Moon was 29′. 54″, and again 29′. 48″.

The Shadow was very thin, whence aroſe ſome Difficulty to diſtinguiſh the Moments of Emerſion and the End. And even the obſcurer Spots were plainly ſeen ſeveral Minutes before they reach'd the Margin of the Shadow. The Star which was hid during the Eclipſe was then in ♓ 17°. 16′½, with Southern Latitude 1°. 6′. 30″. very near.

We have alſo received Obſervations of this Eclipſe from the Rev. Mr. *Derham*, made at *Upminſter* in the County of *Eſſex*; from Mr. *Wright* at *Crew* in *Cheſhire*; and from Mr. *Hawkins* at *Wakefield* in the County of *York*; every where almoſt agreeing with the foregoing, having Regard to the Difference of Meridians: That is, ſuppoſing *Upminſter* to be 1½ Minutes more Eaſterly than *London*, *Crew* to be 10 Minutes, and *Wakefield* 5 Minutes, more to the Weſt.

Laſtly, to ſum up all, we will add a very notable Obſervation, and the firſt of its Kind that we know of, ſince the Diſcovery of the Teleſcope, and which we owe to the unwearied Application of Dr. *James Bradley*. For on the 5th of *September* in the Morning, the Sun being nearly 30 Degrees high, he ſaw at *Wanſtead* a moſt near Tranſit of the Moon below the *Bull*'s *Eye*, the Diſtance of which from the next Limb he found with a Micrometer to be 5′. 38″. at 7^h. 59′. 0″. of equal Time. At 8^h. 17′. 5″. it was diſtant from the Limb 1′, 25″. And at 8^h. 33′, 15″. the Star was in a right Line through the Cuſpids of the Moon, which at that Time were ſomething blunted, nor was it diſtant from the Northern above 0′. 13″. and at 8^h. 41′. 0″. it had left that Cuſpid 3′. 42″. And at 8^h. 45′. 37″. it was diſtant from the ſame 5′. 36″. The Moon's Diameter taken at 8^h. 58′. was 31′. 7″.

XXXIX. Our late Obſervations are theſe; 1718, *Octob.* 10, in the Morning, *Jupiter* applied to the Teleſcopic fixt Stars, the Places of which the Rev. Dr. *Pound* has carefully enquired into, on Occaſion of the firſt Appearance of the Comet of the Year 1680, (of which ſee *Phil.* * *Tranſ.* n. 342.) and having verified them lately, has communicated them to us, together with an accurate Obſervation of a Tranſit of *Jupiter* near them at this Time, and afterwards another *Feb.* 11. preſently after the Oppoſition of *Jupiter* and the Sun. Now at the Beginning of *January* 1719, the Places of the Stars were thus.

A Collection of Aſtronomical Obſervations for 1719, by — n. 263. p. 1109. — *of the* Planets.

* *Vid.* infra, §XLI.

		Longitude.	*North Latitude.*
d	♌	29°. 59′. 43″	1 : 7 . 50
e	♍	0 . 6 . 13	1 . 10 . 18
c	♍	0 . 3 . 13	0 . 32 . 50
a	♍	0 . 25 . 41	1 . 28 . 54
x	♍	0 . 5 . 43	0 . 51 . 56

Where it is to be obſerved, that the Stars *d* and *e* have the ſame Declination exactly in this our Age; but *x* is a very little Star, which becauſe of its Smallneſs was omitted in the former Deſcription.

Now *Octob.* 9°, at 17^h. 5′. equal Time, the Eaſtern Limb of *Jupiter* reach'd the Line joyning the Stars *e* and *c*, and at the ſame Time his Center was diſtant from *e* 21′. 20″. and from *c* 16′. 25″. and was preſently diſtant from *d* 19′. 35″. The little Star *x* being very near *Jupiter* was hid, or overpower'd with his Light.

Dec. 11. at 18^h. 30′. equal Time, the Center of *Saturn* was diſtant from μ in *Libra* (according to *Bayer*) 28′. 32″. and was more to the North than the fixt Star by 4′. 31″. Hence the Obſerver Dr. *Pound* concluded the Place of *Saturn* to be ♏ 1°. 41′. 10″. with Northern Latitude 2°. 16′. 43″.

Fig . 114.

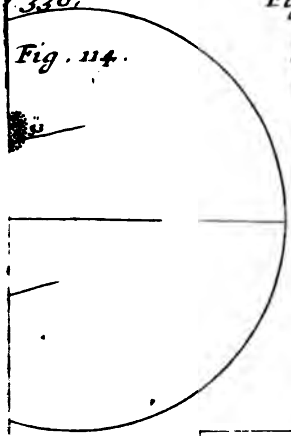


Fig. 118.

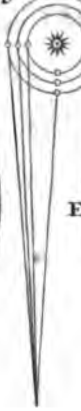
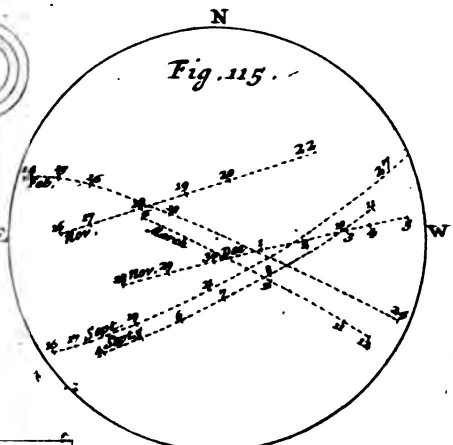


Fig. 115.



ig. 117.

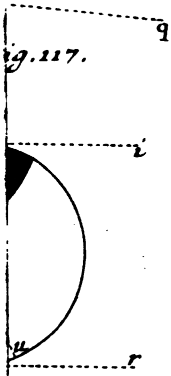
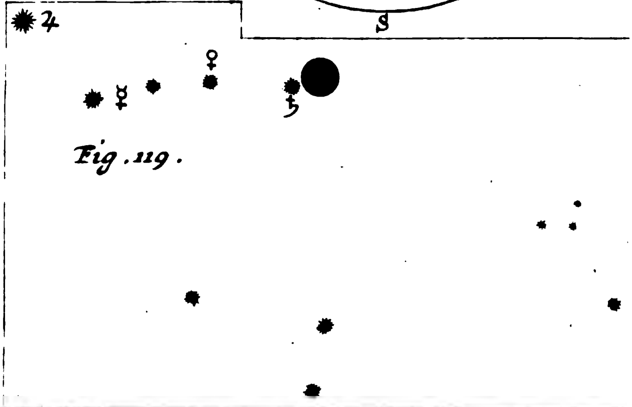


Fig. 119.



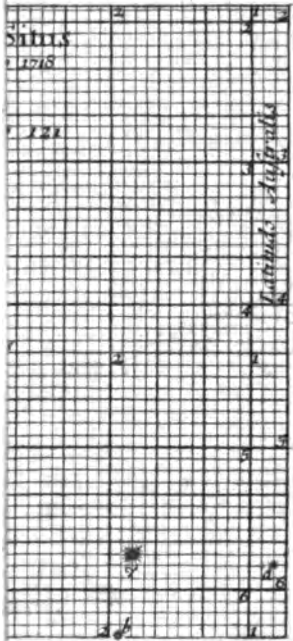


Fig. 123.

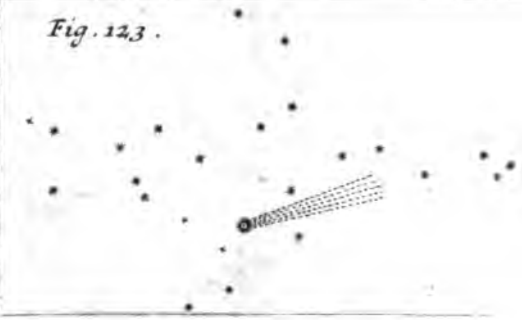
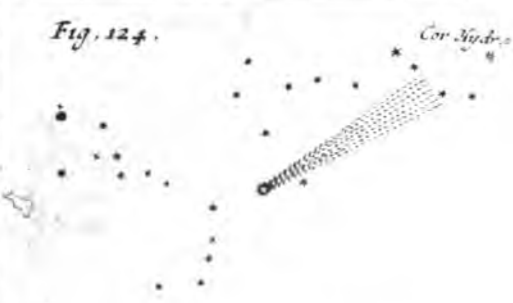


Fig. 124.



1719, *Feb.* 11. at 6^{h}. 56′½. equal Time, the Center of *Jupiter* being retrograde was diſtant from the above deſcribed Star —— 10′. 42″
6 . 58¼ The ſame Center was diſtant from *e* —— 6 . 7
9 . 37½ The Diſtance taken again from *d* — —— 10 . 9
9 . 43½. Again from *e* —— —— 6 . 11
9 . 49½ The Center of *Jupiter* was diſtant from *a* —— 25 . 21
9 . 58½ The ſame Center from the ſmall Star *x* —— 24 . 38

About Seven a-Clock the Eaſtern Limb of *Jupiter* reach'd the Line extended through *x* and *e*; *Jupiter* then was in ♍ 0°. 6′. with North Latitude 1°. 16′. 30″. Then

Feb. 13, at 8^{h}. 0′, equal Time, the Declination of *Jupiter*'s Center, meaſured by the Micrometer, was more Northerly than that of either of the Stars *d* and *e*, by 11′. 37″. and at 8^{h}. 20′. the ſame Difference was found 11′. 36″. But at 8^{h}. 48′. the Center of *Jupiter* was diſtant from *e* 17′. 40″.

April 22, at 10^{h}. 45′. equal Time, the Center of *Saturn* follow'd μ in *Libra* 4′½ Minutes of Time, or 1′. 8″. of Right Aſcenſion. Being meaſured with the Micrometer, he was found more Northerly than the fixt Star 35′. 25″. Now in the *Britiſh* Catalogue the Star was then in ♏ 10°. 16′. 8″. North Latitude 2°. 3′. 54″.

May 16, at 8^{h}. 0′. equal Time, *Jupiter* follow'd *Cor Leonis* at 1°. 34′½. of Right Aſcenſion; but was 0′. 41″½. more to the North than that Star. In Time this is 10′. 7″. of an Arch of the Heavens.

The ſame Night at 15^{h}. 18′. apparent Time, Mr. *Stephen Gray* obſerved *Mars*, in reſpect of Right Aſcenſion, to follow the Eaſtern Star in the Tail of *Capricorn* at 16′. 15″. and at the ſame Time it was more to the South than the fixt Star only 0′. 11″.

June 7, at 10^{h}. 15′. apparent Time, *Jupiter* being direct, return'd again to the ſaid Teleſcopic Stars, and then follow'd the Star *d* at 0′. 35″. of Right Aſcenſion, and at 10^{h}. 30′. the Star was diſtant from the neareſt Limb of *Jupiter* 4′. 18″.

The next Day, *June* 8, at 10^{h}. 20′. *Jupiter* follow'd the other Star *e* at 1′. 30″. of Right Aſcenſion, and immediately the Diſtance of the neareſt Limb of *Jupiter* from the Star was taken with the Micrometer 7′. 30″.

July 5, at 8^{h}. 26′. apparent Time, *Jupiter* and *Venus* were in cloſe Conjunction; ſhe more to the North, then preceded *Jupiter* according to Right Aſcenſion 1′. 20″. But the Diſtance of their Centers being taken, or the middle Diſtance of ten repeated Diſtances was 13′. 36″. *Martin Folkes*, Eſq; a great Cultivator of theſe Sciences, communicated theſe three Obſervations made at *London*.

Auguſt 3, at 12^{h}. 20′ equal Time, *Mars* nearly Acronich follow'd the Star τ of *Aquary* (according to *Bayer*) at 10′. 58″. of Time, or 2°. 44′. 57″. of Right Aſcenſion. *Mars* was only 0′. 36″. more to the North than the Star. Whence the Place of the Star being granted as in the *Britiſh* Catalogue, the obſerved Place of *Mars* will be ♓ 7°. 10′. 11″. with South Latitude 6°. 38′. 10″.

Auguſt 10, at 11^{h}. 50′, equal Time, *Mars* follow'd the leſſer Star which precedes τ in *Aquary* 1°. 39'. 30''. in reſpect of Right Aſcenſion, but more Southerly than the fixt Star 10'. 42''.

Auguſt 16, at 7^h. 18'. equal Time, *Spica Virginis* preceded the Center of *Venus* 5''¼ of Time, or 1'. 20''. of Right Aſcenſion, more Southerly than the Planet 18''¼ of Time, or 4'. 35''.

Auguſt 17, *Mars* the Day before Achronich, and next the Earth, was obſerved at two contiguous little Stars, for the Sake of inveſtigating his Parallax, according to the Method exhibited by M. *Caſſini*, in his Book concerning the Comet of the Year 1680. Whence we ſhall endeavour to deduce the Parallax of *Mars* in the next Tranſaction. Now the more Northerly of theſe little Stars was then in ♓ 3°. 5'. 50''. with South Latitude 6°. 6'¼ nearly. But the more Southerly one was in ♓ 3°. 5'. 30''. with South Latitude 6°. 10'¼ nearly. But at 10^h. 40''. equal Time, *Mars* follow'd that to the South 41'. 40''. of Right Aſcenſion, and was more to the South than it 7'. 50''.

Sept. 18, at 9^h. 20'. equal Time, *Mars* was ſeen to precede the Star which in the *Britiſh* Catalogue is the 33 of *Aquary*, by 3'. 45''. of Time, or 56'. 24''. of Right Aſcenſion; and at the ſame Time the Star was more Northerly than the Northern Limb of *Mars* only by one Diameter of the Planet. The Place of the Star was ♒ 29'. 57''½. South Latitude 4°. 48'½.

Oct. 30, in the Evening, at 5^h. 45'. apparent Time, *Mars* was near two contiguous Stars at *b* ♒ by *Bayer*, which are ♒ the 73 and 74 in the *Britiſh* Catalogue. It had paſs'd by the right Line drawn through the ſame, and the Angle at the Center of *Mars* was a right one according to Senſe. The more Northern of the Stars had the ſame Declination with the Southern Limb of the Planet. At 5^h. 53'. the Diſtance of the Star from the Center of *Mars* was 2'. 30''. At 5^h. 56'. the Center of *Mars* was diſtant from the third and more Southerly one at *b*, or the 75 of *Aquarius*, 17'. 4''. At 6^h. 18'. the Diſtance of the Center from the more Northerly, or the 73, was 3'. 5''. Hence we may conclude, that at 3^h. 30'. nearly, *Mars* was in Conjunction with the Northerly Star, and left it only one Minute to the North. But the Place of the fixt Star from the *Britiſh* Catalogue was then ♓ 10°. 29'. 0''. with South Latitude 1°. 40'½. And the 74 was then in ♓ 10°. 29'. 50'', with South Latitude 1°. 44'¼.

Nov. 16, at 19^h. 18'. equal Time, *Venus* preceded the Southern Scale of *Libra* 3'. 13''. of Time, or 48'. 23''. of Right Aſcenſion, and at the ſame Time the Center of *Venus* was more Northerly than the fixt Star 7'. 45''. *Venus* was ſtationary as it were at her aſcending Node.

Dec. 3, at 19^h. equal Time, *Saturn* preceded the third at ζ of *Libra*, or *Libra* 29, by the *Britiſh* Catalogue 0'. 46''. of Time, or 11'. 32''. of Right Aſcenſion. It was more Southerly than the fixt Star 15'. 29''. the Difference being taken by a Micrometer. Whence the Place of Saturn was ♏ 20°. 25'½. with North Latitude 2°. 5'¼.

— *of the* Moon *and* Eclipſes. *Vid.* ſup. p. 332.

We have given above * an Obſervation of the Lunar Eclipſe, *An.* 1717, *March* 15, Afternoon, *Old Style*, made at *Cambridge* in *New-England*, which becauſe of Clouds was not ſeen by us. There the Eclipſe ended at 11^h.

42'$\frac{1}{10}$ nor at that Time had we any other Obſervation of it. But afterwards Mr. *Chandler*, a Captain of one of the King's Ships, brought us from *America*, and communicated to us the Phaſes of the ſame Eclipſe, as they were obſerved at *Lima* in *Peru*, by D. *Peter Peralta* the King's Mathematician, and there printed. He makes the Beginning of the Eclipſe at *Lima*, at 8^h. 4'. 8''. and the End at 11^h. 19'. 55''. At the ſame Time the ſaid Mr. *Chandler* communicated his own Obſervation, made at an Iſland which they call *Virgin Gorda*, where the Eclipſe ended at 12^h. 13'. Afternoon. Becauſe of a clear Sky the End was ſeen very diſtinctly. Among the Acts of the Royal Academy of Sciences for that Year, we alſo find two Obſervations of this Eclipſe agreeing very well with ours; one made by M. *Caſſini*, the other by M. *de la Hire* in the Royal Obſervatory. This makes the Beginning at 13^h. 54'. But the End more ſurely at 16^h. 38'. 10''. The other puts the Beginning at 13^h. 55'. and the End at 16^h. 38'. 25''. The greateſt Obſcuration with this was $7\frac{1}{2}$ Digits, with the other $7\frac{1}{2}$ Digits.

Hence from the End, which ſeems to be taken more accurately in each Place, the Difference of Longitude between *Paris* and *Lima* is 5^h. 18'. 20''. Between *Paris* and *Cambridge* 4^h. 55'. 50''. Between *Paris* and the *Iſland Virgin Gorda* 4^h. 25'. 20''. From which if you ſubtract 9'. 40''. there will come out the Longitudes to the Weſt of *London*; that of *Lima* 77°. 10'. of *Cambridge* in *New England* 71°$\frac{1}{2}$. And laſtly of the Iſland *Virgin Gorda* 63°. 55'. Whence the Geographers may correct with Certainty the Situation of the neighbouring Iſlands.

The other Eclipſe of the Moon of the ſame Year, *Sept.* 9, in the Evening, was ſeen by the ſame Obſervers, and M. *Maraldi* at *Paris*. In the Houſe of the Royal Society at *London*, we obſerved the End at 7^h. 26'. At *Paris* the End was obſerved by M. *Caſſini* at 7^h. 34'. 50''. by M. *Miraldi* at 7^h. 35'. 30''. and by M. *de la Hire* at 7^h. 34'. 15''. Alſo M. *Wurtzelbaur* at *Norimburg* ſaw the ſame End at 8^h. 10'. 45''. Hence the Difference of Meridians is confirm'd between *London* and *Paris*, eſpecially from the Obſervation of M. *Maraldi*, to be 9'. 30''. as alſo between *London* and *Norimburg* 44'. 45''. The ſame we have often found before. Now on the fifth Day after the Eclipſe, *Sept.* 14, in the Evening, at *Paris* the Moon eclipſed the *Bull's Eye*, as M. *Maraldi* and M. *Deliſle* the Younger obſerved ſeparately. The Star diſappear'd over againſt the Spot *Grimaldi*, or *Palus Mareotis*, at 9^h. 11'. 35''. And it emerged from the obſcure Limb of the Moon at 10^h. 3'. 55''. We have given above * an Obſervation of this Occultation at *London*.

* *Vid.* ſupra, p. 332.

We are obliged to the Rev. Dr. Pound *for thoſe Obſervations, in which equal Time is made Uſe of; being taken with a Teleſcope of* 15 *Feet, they may be eſteemed as very accurate.*

Obſervations *at* Rome *on the Comet,* 1664. *by the late* Mr J. Ray, *communicated by* Mr S. Dale n. 309. p. 2350.

XL. *December* the 20th, 1664, *N. S.* about Three a-Clock this Morning, I obſerved the *Comet*; it was in the Conſtellation of *Hydra*, not far from the Foot of *Crater*. It appeared about the Bigneſs of a Star of the firſt Magnitude, but nothing ſo lucid and bright. It had a very long Tail, which pointed almoſt directly towards the Heart of *Hydra*: The Tail ſhewed ſomewhat like Rays of a Candle burning in a Miſt; the Figure of it was conical;

Fig. 123. the Length of it 5 or 6 Degrees; the Breadth at the Baſe not above a Degree and an Half. The Body of this *Comet* was about 3 Degrees to the South-Eaſt of the moſt Southerly Star in the Foot of *Crater*; it ſtood very near in a Right Line with the two lowermoſt Stars in the Foot of *Crater*, which are common to it and *Hydra*.

Fig. 124. *December* 21, In the Morning, about the ſame Hour, it was removed about a Degree and an Half from the Place where it ſtood, Weſtward, and a little to the South. The Tail pointed ſtill towards the Heart of *Hydra*, and appeared 10 Degrees long at the leaſt.

Fig. 125. *December* 22, At the ſame Time it was removed from the Place where it ſtood the Day before, to the ſame Point, and about the ſame Diſtance as the Night before. The Tail of it ſtill pointed to *Cor Hydræ*, or a little Thought above it, as the two former Days, and was rather longer than ſhorter: It alſo, to my Thinking, appeared brighter and larger; the Body of it being bigger than any fixt Star, except *Sirius*.

Fig. 126. *December* 23, It was removed to the ſame Point, and about the ſame Diſtance as the Day before; the Tail of it was as long as ever, and the *Comet* brighter. The Tail pointed almoſt directly to *Cor Hydræ*.

December 24, 25, 26, All theſe three Nights were cloudy, ſo that I could make no Obſervations.

Fig. 127. *December* 27, We found it ſtrangely removed from the Place where it was: It was ſtill Weſtward, and a little to the South, as before. The Body of the Star was ſtill brighter, and the *Cauda* about it greater, and more buſhy, and yet as long as before; it pointed almoſt directly againſt *Canis major*. The Body of it was amongſt the Stars of *Argo*.

Fig. 128. *December* 28, The ſame Time it was removed above two Degrees towards the ſame Point, and come within four or five Degrees of the moſt Eaſtern Stars in the bright Triangle in the Buttocks of *Canis major*. The *Moon* ſhining, we could not ſo well judge, either of the Bigneſs of the Body, or the Length and Buſhineſs of the Tail.

Fig. 129. *December* 29, It was ſtrangely removed, and got before, not the Eaſtern Star only of the mentioned bright *Triangle*, but alſo the moſt Northern. I think, at leaſt, in this laſt twenty-four Hours, it had moved four Degrees. The *Moon* ſhining bright, the Tail could not well be obſerved, yet ſtill it ſeemed to point directly to *Canis minor*.

Obſervations *on the* Comet 1680. *ſeen in* Saxony, *by Mr.* G. Kirch, *by* — n. 342. p. 170.

XLI. The Comet, which was ſeen at the End of the Year 1680, for many Reaſons is to be conſider'd as the principal of its Kind; as well on Account of its Courſe for four Months, in which it paſs'd through nine whole Signs, as becauſe of the immenſe Magnitude and Brightneſs of its Tail: But chiefly of the remarkable Curvity of its Orbit, by the Help of which the Theory of Comets is at laſt diſcover'd by the illuſtrious *Newton*, who firſt of all Mortals proved that Comets deſcribe Orbs, which very nearly approach to the Form of Parabolic.

Now it happen'd, I know not by what Fate, that this Comet, (which in the Evening was ſo much attended to by Aſtronomers,) in the Morning before it reach'd the Sun, was not once obſerv'd either at *Paris* or at *Greenwich*. And thoſe that ſaw it and obſerv'd it, deliver'd incongruous and contradictory Things about it, and but little ſuitable to the Nicety of the Affair. Nor was it ſeen by any intelligent Obſerver till *Nov.* 17, in the Morning. Hence it was that that Part of the Orbit, in which the Comet approach'd towards the Sun, could not be determin'd but with ſome uncertainly. But we lately happen'd upon a Book of a very deſerving Aſtronomer Mr. *Gottfried Kirch*; a *German*, printed at *Norimberg*, *An.* 1681, called Neue Himmels zeitung, that is, a new Celeſtial Meſſenger; in which the very diligent Author explains to us, by what good Fortune he diſcover'd this Comet, being as yet obſcure without a Tail, and hardly viſible to the naked Eye: While he was taking his View in order to obſerve the Moon and *Mars* that was near her, *Nov.* 4, old Stile, in the Morning, at *Coburg* in *Saxony*, which Town is 11 Degrees more Eaſterly than *London*, under the Pole's Altitude 50°. 20′. nearly; he was urged, as he ſays, by the Rumour of a Comet ſeen in *Germany*; and ſat up at Night with his Face towards the Eaſt, that if any Thing new ſhould ariſe in the Heavens, which were then very ſerene, he might take Notice of its Situation. Now as the Moon approach'd to a certain Star, not taken Notice of by *Tycho*, (but which is put down in *Flamſtead's Britiſh* Catalogue, and is 44 in *Leo*,) he had a Mind to determine the Place of the ſaid Star by thoſe which were near it; and as he turn'd about his Tube which was capable of receiving three Degrees, he fell upon a Kind of cloudy Light, making an unuſual Appearance, and which he immediately concluded to be either the new Comet, or a nebulous Star like that which is in *Andromeda*'s *Girdle*.

Now he firſt ſaw the Comet at $4^{h}\frac{1}{2}$ in the Morning, being a little higher than the two little Teleſcopic Stars, which are mark'd with the Letters *a* and *o*, with which however at 6^{h}. it was exactly in a right Line. Whence it was plain that it moved, and with a direct Motion. Between the Hours of Five and Six he view'd this Phenomenon with a 10 Foot Tube, and ſaw two other little Stars contiguous, but leſs than the former, mark'd with the Letters *e* and *d*, and above thoſe a third *g*. Now the Diſtance of the Comet from *e* was ſomething leſs than that from *a*, but greater than the Diſtance *d e*. At 6^{h}. 38′. the Diſtance of the Comet from *e* was the Double of the Interval between them *d e*, and the Line *d e* produced left the Comet * below it, yet ſo that it reach'd its upper Margin. At 6^{h}. 45′. the Comet was now inſenſibly more remote from *e* than from *a*, and was diſtant from *a* ſomething more than half the Diſtance of the little Stars *a* and *g*. Fig. 130.

Now it is to be obſerved, that the Clock was before the Heavens full 14 Minutes, as appeared from the Altitudes of *Cor Leonis* which were then taken.

This is truly a noble Obſervation, and therefore we have inquired into the Places of the little Stars then adjoining to the Comet by more than one Method; Mr. *James Pound* affording us his moſt expert Hand and very excellent Inſtruments. Whence it appear'd, that at that Time thoſe little Stars had the following Situations.

	Longitude.				*Latitude.*			
a	♌	29°	54	20″	1	29	20	North.
b		29	27	20	1	8	00	
c		29	34	30	1	10	45	

Now

* By a Tube inverting the Objects.

Now a great Circle drawn through *a* and *c* was found to paſs through the laſt Star of the Tail of the greater Bear, and therefore that the Angle with a Circle of Longitude at *a* was 15°. 36′$\frac{1}{2}$. And whereas the Diſtance of the Comet from *a* towards *c* was ſomething greater than half the Diſtance *ag*; (which with a Tube of 16 Feet, and a Micrometer, we find to be 21′$\frac{2}{5}$,) we may ſuppoſe it to have been 12 Minutes. And from what is given the Place of the Comet will come out ♌ 29°. 51′. with North Latitude 1°. 17′$\frac{3}{4}$. The Hour of the Clock being 6, but at *London* 5h. 2′. apparent Time.

Again, *Nov.* 6, in the Morning, at 4h. 42′. with a two Foot Teleſcope he found the Comet to be juſt in a right Line between *Mars* and the little Star *N*; which in the *Britiſh* Catalogue is the 45 of *Leo*, and was then in ♍ 2°. 42′. with South Latitude 0°. 16′$\frac{1}{2}$. but *Mars* at that Time, (by comparing Obſervations made before and after) was in ♍ 3°. 46′$\frac{1}{2}$. with North Latitude 1°. 56′. Whence, becauſe of its Part being given, the Comet was in ♍ 3°. 23′. with North Latitude 6′, at *London* at 3h. 58′. apparent Time, in the Morning.

Fig. 131. Alſo *Nov.* 11, at 5h. 15′. in the Morning, the Comet was equally diſtant from the Stars σ and τ of the *Lion*, according to *Bayer*, but had not yet reach'd the right Line joining the ſame, but was at a little Diſtance from it. In the *Britiſh* Catalogue σ was then in ♍ 14°. 15′. with North Latitude 1°. 41′. nearly; and τ was in ♍ 17°. 3′$\frac{1}{2}$. with South Latitude 0°. 34′. Therefore the Latitude of the Comet was ſomething leſs than a Mean between them, that is, than 0°. 33′$\frac{1}{2}$ Northerly; and its Longitude than ♍ 15°. 39′. But this is not to be much rely'd on, ſince it depends upon the eſtimated Equality of the Diſtances, which is a ſlippery Matter. Now the Tail was not yet begun, except by the Length of half a Degree, view'd by a ten Foot Tube.

He that would know more muſt have recourſe to the Book itſelf, wrote in the *German* Language.

Obſervations on a Comet *ſeen in* 1718, *at* Berlin, *by* *Mr.* G. Kirch, n. 357. p. 840.

XLII. Mr. *Chr. Kirch*, *Jan.* 18, new Stile of the preſent Year, as he was diligently obſerving the Motions of the Heavenly Bodies, in the Evening in the Middle of the Week, by chance perceived a Comet towards the North. It was near and to the Right Hand of *Bayer*'s Stars γ and β in the leſſer *Bear*, and appear'd much more diſtinct to the naked Eye than β in *Urſæ minor*, tho' that be a remarkable Star of the ſecond Magnitude; it being indeed much paler, yet of a greater Diameter, and of a pretty bright Light, eſpecially towards the Center. When ſeen through the Tube it ſhew'd as a bright round little Cloud; but no Foot-ſteps of a Tail could be obſerved, nor any Nucleus. It went on with a very ſwift Motion from the Hour Seven to Eleven, and compleated 4$\frac{1}{2}$ Degrees, as was concluded by Obſervation.

Jan. 19 and 20, the Heavens were cover'd with Clouds. But on the 21*ſt* the Comet had departed far from its former Place, and was found in *Caſſiopea*, where it made a Triangle (was it equicrural?) with the Stars ε and δ, at 5h. 45′. in 17°. 34′. ♉, under Northern Latitude 49°. 54′. Afterwards at 9h. 15′. it was ſeen in 16°. 38′. ♉, under Northern Latitude 49°. 2′.

2′. But it was much decreaſed, and came ſhort of its former Velocity; as alſo it appear'd paler than before, and being ſeen with the naked Eye, ſeem'd hardly to exceed in Magnitude a Star of the fourth Dignity; and had proceeded in its Orbit not above a Degree and a Half in four Hours and a Half. By the Aſſiſtance of the Tube its Diameter was found to be ſeven Minutes.

Jan. 23, at Four in the Morning, the Comet made an equicrural Triangle with δ and φ in *Caſſiopea*, being diſtant 2°. 41′½. from each. This Morning it hardly moved half a Degree in the Space of two Hours. At Ten in the Evening it was ſeen in a right Line with δ of *Caſſiopea* and φ of *Perſeus*, and was diſtant from the former 3°. 38′. from the latter 3°. 9′. Its Diameter was five Minutes, and view'd with the naked Eye ſeem'd a Star of the fifth Magnitude.

Jan. 24, at Six in the Morning, it had not reach'd φ of *Perſeus*, but made an equicrural Triangle with υ and *g* of the ſame Conſtellation, and was diſtant from each not quite 3° ½. This very accurate Perſon will inform us of more Things from his Obſervations, in that more copious Hiſtory of this Comet, which he is now preparing.

Hitherto the Treatiſe call'd the Literary Journal, *p.* 43, 44, *in which are wanting the Obſervations of the* 18*th Day, when the Comet was neareſt to the Earth, and moved with greateſt Velocity, whence we might make a ſurer Judgment of its true as well as apparent Courſe. Now it is evident that on* Jan. 19, *it paſſed neareſt to the Northern Pole of the Equator. If any one ſhould have a Mind to bring theſe Obſervations to a Scrutiny, and to make them ſubmit to a ſtricter Calculation; for this Purpoſe here are ſubjoined the Places of the fixt Stars here mention'd, taken out of the* Britiſh *Catalogue; whence it will plainly appear, that ſome Things cannot be right in the Deſcription of the Motion of this Comet, which we hope will be corrected in that fuller Account which he promiſes.*

The Places of the fixt Stars at the Beginning of An. 1718.

According to *Bayer*.		Longitude.				North Lat.		
			°	′	″	°	′	″
Of *Urſa Minor*	β	♌	9	18	0	72	58	10
	γ	♌	17	35	15	75	13	15
Of *Caſſiopea*	δ	♉	14	00	35	46	23	25
	ε	♉	20	50	8	47	31	50
	φ	♉	11	36	35	45	4	5
Of *Perſeus*	υ	♉	8	32	0	35	23	45
	φ	♉	10	41	35	36	49	15
	g	♉	12	15	20	36	18	37

XLIII. That

A ſmall Teleſcopical Comet *ſeen* June 10, 1717, *by Dr.* E. Halley, n. 354. p. 721.

XLIII. That the Number of Comets is much greater than ſome, on Account of the late Rareneſs of their Appearance, have ſuppoſed, may be collected from ſeveral ſmall ones, which have within few Years been deſcribed in the Memoirs of the *French* Royal Academy of Sciences; thoſe Obſervers aſſuring us, that they diſcovered one in *Sept.* 1698. another in *Feb.* 1699, a third in *April* 1702, and again a fourth in *Nov.* 1707, none of which, as far as I can learn, were ever ſeen in *England*; all of them having been very obſcure and without Tails, by Means whereof Comets uſually firſt ſhew themſelves. And beſides theſe, two other Comets with remarkably long Tails, the one in *Nov.* 1689. the other in *Feb.* 1702. paſt by unobſervable in theſe our Northern Climates, they having great Southing Latitude, and their Motions directed toward that Pole. Hence we may juſtly conclude, that the Returns of Comets are much more frequent than is vulgarly reckoned, and that it is only contingent, that for theſe Thirty Five Years no one of them has been ſeen and obſerved by our Aſtronomers.

But there may be ſtill a much greater Number of theſe Bodies, which by reaſon of their Smallneſs and Diſtance are wholly inviſible to the naked Eye; ſo that unleſs Chance do direct the Teleſcope of an Obſerver, almoſt to the very Points where they are, it will not be poſſible for them to be diſcovered: And that this is not barely a Conjecture, take the following Inſtance.

Vid. Supr. p. 224.

On *Monday June* 10, in the Evening, the Sky being ſerene and calm, directing my Twenty-four Foot Teleſcope towards *Mars*, I accidentally fell upon a ſmall whitiſh Appearance near the Planet, reſembling in all Reſpects ſuch a *Nebula* as I deſcribed in *Phil. Tranſ.* N°. 347. but ſmaller. It ſeemed to emit from its upper Part a very ſhort Kind of Radiation directed towards the Eaſt, but Northerly withal; which, conſidering its Situation, was nearly towards the Point oppoſite to the Sun. The great Light of the Moon, then very near it, and alſo near full, hindered this *Phænomenon* from being more diſtinctly ſeen; but its Place in the Heavens was ſufficiently aſcertained from the Neighbourhood of *Mars*, from whom it was but about half a Degree diſtant towards the Southweſt, the Difference of Latitude being ſomewhat more than that of Longitude; and *Mars* being at Time in ♐ 17°. 30′ with 3°. 48′ South Latitude. I concluded the Place thereof in ♐ 17°. 12′. with 4°. 12′. Latitude South, or thereabouts; the which may yet be more ſecurely determined by Help of two ſmall fixt Stars I found near it, the more Northerly of which I judged to have the ſame Latitude with it, and to follow it at about the Diſtance of ſix Minutes; the other Star was about four Minutes more Southerly than the former, and about one Minute in conſequence thereof; the Angle at the Northern Star was a little obtuſe, as of about 100 Degrees, and the Diſtance of our *Nebula* from it *Seſqualter* to the Diſtance of the two Stars, or rather a little more. The Reverend Mr. *Williams*, Mr. *Thomas*, and myſelf, contem-

Pag. 344

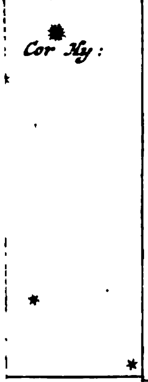
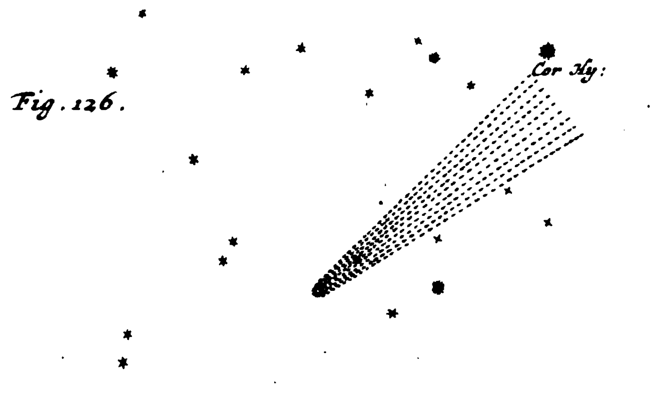
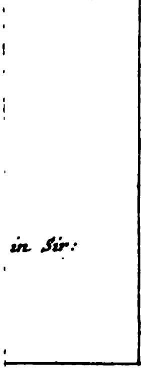


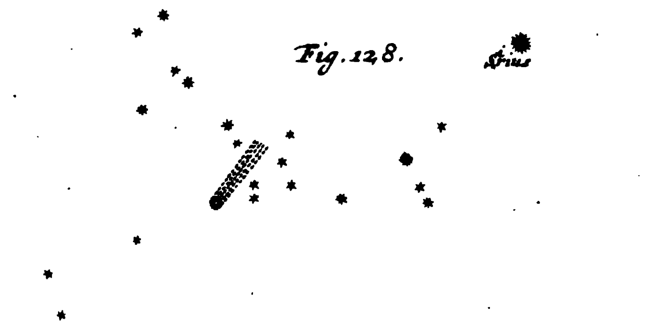
Fig. 126.





Hoc ſchema vero ſitui Stellaru: propius

Fig. 128.

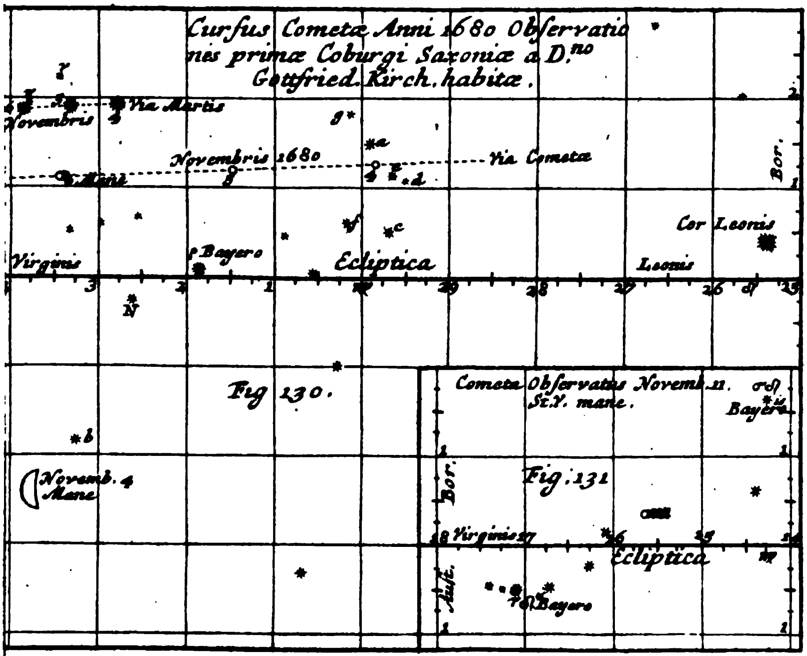


Curſus Cometæ Anni 1680 Obſervationes primæ Coburgi Saxoniæ a D.no Gottfried. Kirch. habitæ.

Fig 130.

Cometa Obſervatus Novemb. 11. St.V. mane.

Fig. 131



plated this Appearance for above an Hour, *viz.* from half an Hour paſt 10 to near 12, and we could not be deceived as to its Reality; but the Slowneſs of its Motion made us at that Time conclude, that it had none, and that it was rather a *Nebula* than a *Comet*.

However, ſuſpecting that it might have ſome Motion, I attended the next Night at the ſame Hours, and in the ſame Company; when with ſome Difficulty, by Reaſon of the Thickneſs of the Air, we found the two little Stars; but the *Nebula* could not at that Time be ſeen, which we then imputed to the Want of a clearer Sky: But on *Saturday June* 15, the Moon being abſent, and the Air perfectly clear, we had again a diſtinct View of the two Stars, with an entire Evidence that there remained no Footſtep or Sign of it in the Place where we had firſt ſeen this *Phænomenon*, which we therefore now found to be a Comet, and that being far without the Orb of the Earth, and in itſelf a very ſmall Body, it appeared only like a little Speck of a Cloud, ſuch as would ſcarce have been diſcerned in an ordinary Teleſcope, much leſs by the naked Eye.

XLIV. *Papers omitted.*

1. Extracts from Mr. *Gaſcoigne*'s and Mr. *Crabtrie*'s Letters, proving Mr. *Gaſcoigne* to have been the Inventer of the *Teleſcopick Sights* of Mathematical Inſtruments, and not the *French*, by the Reverend Mr. *W. Derham*, Prebend of *Windſor*, and F. R. S. n.352. p.603.

Mr. *De la Hire*, in the firſt Part of his *Tabulæ Aſtron.* publiſhed in 1687, having aſcribed to Mr. *Picard* the *Application of Teleſcopick Sights to Aſtronomical Inſtruments* (which alſo was in Effect claimed as his, by Mr. *Auzout*, in a Letter in the *Ph. Tranſ.* N. 21. in the Year 1666.) Mr. *Derham*, from theſe Letters of Mr. *Gaſcoigne* and Mr. *Crabtrie*, proves that Mr. *Gaſcoigne*, as early as the Year 1640, made Uſe of theſe *Teleſcopick Sights* in two or more Sorts of his *Micrometers*, and in his *Quadrant* and *Sextant*.

2. Aſtronomiæ *Cometicæ* Synopſis, Autore *Edmundo Halleio* apud *Oxonienſes* Geometriæ Profeſſore *Saviliano*, & R. S. S. n. 292. p. 1882.

XLV. *Account of a Book omitted.*

Aſtronomiæ Phyſicæ & Geometricæ Elementa, Auctore *Davide Gregorio*, M. D. Aſtronomiæ Profeſſore *Saviliano*, & R. S. S. *Oxoniæ*, 1702. *Folio.* n. 283. p. 1312.

CHAP. IV.

Mechanics. Acouſtics.

To find a Solid of the leaſt Reſiſtance, &c. by Mr. J. Craig, n. 268. p. 747. *Dec.* 21. 1700.

I. 1. THE Problem of finding a Round Solid, which moving in a Fluid ſhall ſuffer the leaſt Reſiſtance, which was formerly ſolved by the Illuſtrious *Newton*, has been lately attempted by thoſe great Men the Marquiſs of *Hoſpital* and Mr. *J. Bernoulli*; becauſe Mr. *Newton* thought fit to ſuppreſs his Analyſis. Our Solution of the ſame Problem is as follows.

Lemma. To find the Ratio between the Reſiſtance which the right angled Triangle AIG ſuffers, and the Reſiſtance which the circumſcrib'd Rectangle $AIGg$ ſuffers, when both are moved in a Fluid according to the Direction of the Line IA, from I towards X.

Fig. 135. From any Point B let BC be drawn perpendicular to AG; and Bb parallel to AI, alſo BM perpendicular to AI. Then in Bb take $bH = \frac{CMq}{BC}$, and $bE = BC$; and through the Points H, E, draw the right Lines HA, EA, which produced may cut Gg in K and F. I ſay the Reſiſtance of the Triangle AIG is to the Reſiſtance of the Rectangle $AIGg$, as the Area of the Triangle AKG is to the Area of the Triangle AFg. Alſo the Reſiſtance upon any Part of the Line AG is to the Reſiſtance on the correſponding Part of the Line Ag, for Example, on AB and Ab, as the Area AHb to the Area AEb. The Demonſtration depends on the general Theorem, which I eaſily derived from *Prop.* xxxv. *p.* 324. of *Newton*'s *Principia*.

Corol. 1. Now let BG, bg, be infinitely ſmall Parts of the Lines AG, Ag, and let bB be produced to L. I ſay the Reſiſtance upon BG, (which we may call e) is to the Reſiſtance upon bg, (which we may call E) as GLq to GBq.

For $e . E :: KHbg . FEbg$, that is, $e . E :: bg \times bH . bg \times bE$, (by the foregoing *Lemma*;) therefore $e . E :: bH . bE$, that is, $e . E :: \frac{CMq}{BC} . BC$, (by the Conſtruction of the foregoing *Lemma*;) therefore $e . E :: CMq . BCq$. But $CMq . BCq :: GLq . GBq$, (becauſe of the ſimilar Triangles BMC, GLB,) therefore $e . E :: GLq . GBq$. *Q. E. D.*

Corol. 2. The Reſiſtance upon an infinitely ſmall Part GB is equal to the Cube of the Line GL divided by the Square of the Line GB. For if all the infinitely little Parts in the Line Ag, as bg, are ſuppoſed equal, then the Reſiſtance upon bg may be expreſs'd by bg itſelf, that is, $E = bg$, and therefore $E = GL$. Therefore by the firſt Corollary, $e . GL :: GLq . GBq$; whence $e = \frac{GL\,cub.}{GBq}$. *Q. E. D.*

Corol. 3. Let *r* be the Radius and *c* the Circumference of any Circle; I ſay that the Reſiſtance upon a conical Superficies produced by the Rotation of the little Line *G B* about *A I*, is equal to the Product of $\frac{c\times BM}{r}$ into $\frac{CL\,cub.}{GBq}$. For the Reſiſtance upon that Conical Superficies is equal to all the Reſiſtances upon the little Line *G B*, that is, to all the *e*'s; which is equal to the Circumference of a Circle whoſe Radius is *B M*, multiply'd into *e*. That is, the Reſiſtance upon that Conical Superficies is equal to $\frac{c\times BM}{r}\times e$; and therefore by *Cor.* 2. is equal to $\frac{c\times BM}{r}\times\frac{CL\,cub}{GBq}$. *Q. E. D.*

Problem. To find the Curve Line, by the Rotation of which a round Solid is produced, which if moved in a fluid Medium, according to the Direction of its Axis, ſhall ſuffer the leaſt Reſiſtance poſſible.

Fig. 136.

Let *O G*, *G B*, be two infinitely ſmall Particles in the Curve required, which revolving about *A Q* may produce the round Solid of leaſt Reſiſtance. Draw *B M*, *G P*, perpendicular to *A Q*, alſo *B L*, *G N*, parallel to *A Q*, and *O N* parallel to *B M*. Now $\frac{c\times BM\times GL\,cub.}{r\times GBq}$ is the Reſiſtance upon the Superficies produced by the Rotation of the little Line *G B* about *A Q*, and $\frac{c\times GP\times ON\,cub.}{r\times OGq}$ is the Reſiſtance upon the Superficies produced by the Rotation of *O G*, by *Cor.* 3. Now theſe two Reſiſtances taken together, ought to be the leaſt poſſible, that is, $\frac{c\times BM\times GL\,cub.}{r\times GBq}+\frac{c\times GP\times ON\,cub.}{r\times OGq}=$ Min. Therefore in the Line *R S* parallel ſo to *A Q*, that $ON=GL$, the Point *G* is to be ſought that this may happen. Now ſuppoſing the Points *O* and *B* to be fix'd, this will be eaſily found, by the known Method of *Maxima* and *Minima*. By purſuing the Calculation we ſhall come at laſt to $\frac{BM\times BL}{BGqq}=\frac{GP\times NG}{OGqq}$; whence it appears that $\frac{BM\times BL}{BGqq}=$ a conſtant Quantity. Thus if the Abſciſs *A M* is called *x*, and the Ordinate *B M* is *y*, it will be $BL=\dot{x}$, $LG=\dot{y}$, (which I have ſuppoſed to be conſtant in all this Calculation) and therefore $BGq=\dot{x}\dot{x}+\dot{y}\dot{y}$, whence $\frac{y\dot{x}}{\dot{x}^2+\dot{y}^2}=$ conſtant Quantity. Let *a* be any conſtant Line, and therefore (that the Law of Homogeneity may be obſerved) it will be $\frac{y\dot{x}}{\dot{x}^2+\dot{y}^2}=$

$\frac{a}{y^3}$, as is found by the illuſtrious M. *Hoſpital* and the famous Mr. *J. Bernoulli.*

And here by the bye I take this Opportunity to ſignify to Mr. *Bernoulli*, that I am very much pleaſed with his Method of conſtructing Curves from Fluxional Equations, in which one of the indeterminate Quantities x or y is wanting; as it is publiſhed in the *Leipſic Acts* for the Month of *May*, *An.* 1700. And from whence he has deduced the Conſtruction of the Curve here required, *Nov.* 1699. *p.* 515.

—— *on the ſame, by Mr.* N. Facio, n. 337. p. 172. *May* 17, 1712.

2. The celebrated Mr. *John Bernoulli* has wrote many Things about my Solution (printed at *London*) of the Problem for finding a round or taper Solid, againſt which the leaſt Reſiſtance ſhall be made. He denies that it is in my Power, tho' I am quite unknown to him, from ſuch a Solution involved in ſecond Fluxions, to go back to *Newton*'s Solution, a like to which *Bernoulli* himſelf has found. And inſinuates by ſuch Aſſertions, that at the Time *Bernoulli* was writing this, ſuch a Regreſs would be eaſy to him. But the Letters of the celebrated *James Bernoulli* are not a little contrary to this, from which it appears, that at the Time he wrote, neither he nor his Brother were acquainted with that Transformation of ours; of Equations in which Fluxions are involved; in which they are multiply'd for duly determining a Product, ſuppoſe for Inſtance $x^\pi y^\lambda$, or any other complex Quantity. Now under Multiplication alſo Diviſion is contained: Now with this Transformation, found by me in the Years 1687 and 1688, I acquainted Mr. de *Moivre* and Mr. *Huygens*, by whom perhaps the Knowledge might be communicated to others. And upon Inquiry I found, that our moſt worthy Preſident *Newton* at that very Time was not ignorant of it, or rather had found it the firſt of all.

But though I could have anſwered many Ways the Cavils of the famous Mr. *John Bernoulli*, yet I choſe to inſert in the *Leipſic Acts* that Inveſtigation which is far the ſimpleſt of all, and which Mr. *John Bernoulli* could not reject: And from which he might farther underſtand, that he had vainly accuſed of Falſity what I had wrote beſides, of finding the *Line of Quickeſt Deſcent*; duly admitting the Conſideration of the Motion (as it were) of a Ray of Light continually refracted, according to *Fermat*'s Doctrine of Refractions.

What I am to perform is this; I am to commit to Writing an Equation involving only firſt Fluxions, which is rightly deduced from that Equation which I have exhibited in pag. 16. This is what Mr. *John Bernoulli* required, and aſſerts I cannot find any ſuch. Nor can theſe be committed to Writing, but at the ſame Time a Way will be opened to Mathematicians, for the farther Advancement of the more abſtruſe Geometry.

Our little Treatiſe may be conſulted, as to what belongs to the ſecond Figure of the ſame.

Fig. 137, 138. In the adjoin'd Figure let C be the Center of the equicurved Circle

AEF, which in the Point A may coincide as intimately as may be with the Section of the Solid required, whoſe Axis is SY. And the Radius of this Circle will be CA, or $u = \frac{3psx}{tt} - \frac{px}{s}$, which was our Solution.

Make as before $AS = x$, perpendicular to the Axis of the Solid YS, the Fluxion of which $AB = \dot x$ let it be of an invariable Magnitude, and let $BE = \dot y$ be parallel to the Axis; and again raiſe the Perpendicular $EG = \dot x$, and $GF = \dot y + \ddot y$ will be parallel to the Axis.

Now it will be $p . t :: u = \frac{3psx}{tt} - \frac{px}{s} . \frac{3sx}{t} - \frac{tx}{s} = \frac{3\dot y x}{\dot x} - \frac{\dot x x}{\dot y}$; which will be equal to n, or AD, parallel to the Axis, ſuppoſing CD to be perpendicular to the ſame Axis. Make $CD = m$.

Again it will be $p . s :: u = \frac{3psx}{tt} - \frac{px}{s} . \frac{3ssx}{tt} - x = \frac{3\dot y\dot y x}{\dot x\dot x} - x$; which will be equal to m or CD. The Value of this is indeed unneceſſary here, but it will be of Uſe in what follows.

Now from the Property of the equicurved Circle AEF, producing BA and BE to the other Part of the Circumference, we ſhall have $\dot x \times \overline{2m + \dot x} = \dot y \times \overline{2n - \dot y}$.

And again from the Property of the ſame Circle, producing GE and GF to the other Part of the Circumference, we ſhall have $\dot x \times \overline{2m + 3\dot x} = \overline{\dot y + \ddot y} \times \overline{2n - 3\dot y - \ddot y}$.

Therefore ſubſtracting the former Equation from the latter, it will be $2\dot x\dot x = -2\dot y\dot y - \dot y\ddot y + 2n\ddot y - 3\dot y\ddot y - \ddot y\ddot y$.

And thoſe Terms being expunged which are infinitely leſs than the others, it will be $2\dot x\dot x = -2\dot y\dot y + 2n\ddot y$

And the Value of n being ſubſtituted, it is $\dot x\dot x = -\dot y\dot y + \frac{3x\dot y\ddot y}{\dot x} - \frac{x\dot x\ddot y}{\dot y}$; that is $\dot x^3\dot y + \dot x\dot y^3 - 3x\dot y\dot y\ddot y + x\dot x\dot x\ddot y = 0$.

This Equation is composed only of the indeterminate Quantities x, y, and their Fluxions $\dot x$, $\ddot y$, and the invariable Quantity $\dot x$; and of given Coefficients. And there are two Pairs of Terms in which the ſame Letters occur, and Powers of Letters, except that the flowing Quantity expreſs'd by one Letter is converted into a Fluxion, or a Fluxion into a Fluent.

a Fluent. Thoſe Pairs of Terms are $\overset{*}{\dot x^3\dot y} + \overset{*}{x\dot x^2\ddot y}$ and $\overset{**}{\dot x\dot y^3} - \overset{**}{3x\dot y^2\ddot y}$, ariſing only from two generating Terms. For nothing hinders in the whole Equation, but that it may be transform'd, that is, Multiplication being made into $\dot x^{\varkappa}\dot y^{\lambda}$; the Indices $\varkappa$ and λ being rightly determin'd, that by that Means the new Equation ariſing may become manageable.

Therefore according to our Theory of ſuch Transformations, in the generating Term, from whence ariſes the firſt Pair of Terms mark'd with one Aſteriſk, the Number of Dimenſions of the Indeterminate $\dot x$, to the Number of Dimenſions of the Indeterminate $\dot y$, that is, $1+\varkappa$ will be to $1+\lambda$, as the Coefficient 1 in the Term $\dot x^3\dot y$ is to the Coefficient 1 in the Term $x\dot x^2\ddot y$. Again in the generating Term, from whence ariſes the other Pair of Terms mark'd with two Aſteriſks, the Number of Dimenſions of the Indeterminate $\dot x$ will be to the Number of Dimenſions of the Indeterminate $\dot y$, that is, $1+\varkappa$ will be to $1+\lambda$, as the Coefficient 1 in the Term $\dot x\dot y^3$ is to the Coefficient -3 in the Term $-3x\dot y^2\ddot y$; whence it is $\varkappa = -\frac{3}{2}$, and $\lambda = -\frac{3}{2}$, and therefore the Multiplier $\dot x^{\varkappa}\dot y^{\lambda} = \dot x^{-\frac{3}{2}} \times \dot y^{-\frac{3}{2}}$.

Therefore it will be $-x^{-\frac{1}{2}}\dot x^2\dot y^{-\frac{1}{2}} - x^{-\frac{1}{2}}\dot y^{\frac{3}{2}} = \pm q$, which is the generating Equation of the former Equation multiply'd by $\dot x^{-\frac{3}{2}}\dot y^{-\frac{3}{2}}$; where q is a determinate Quantity. Now if you ſquare this generating Equation, (others call it a Fluent) that the Roots may be taken away, there will ariſe $x^{-1}\dot x^4\dot y^{-1} + 2x^{-1}\dot x^2\dot y + x^{-1}\dot y^3 = qq$, or $\frac{\dot x^4 + 2\dot x^2\dot y^2 + \dot y^4}{x\dot y} = qq$. Which is the very Equation of *Newton*, which *J. Bernoulli* has alſo found, and I myſelf have derived formerly, by the moſt eaſy Inveſtigation of all, that can be hoped for this Equation. Now the Quantity qq may be determined, either from the Poſition of the indefinite Axis *YS*, the Point *A*, and the Tangent of the Solid in *A* being given; or from the Poſition of the Point *A*, the Center of the equicurved Circle *C*, and *AD* parallel to the Axis of the Solid being given.

II. *Problem.*

To find the Line of Quickeſt Deſcent, by Mr. J. Craig, n. 268. p. 750. Dec. 21.1700.

II. ***Problem.*** To find the Line of ſwifteſt Deſcent.

Let BC, CD, be two infinitely ſmall Particles in the Curve required. Now this Curve muſt be ſuch, that the Paſſage from B to D, after the Fall from the Horizontal Line AQ, may be perform'd in the ſhorteſt Time. Therefore a Point is to be found in the Line RS, (parallel to a AQ in ſuch a Manner, as that the Differences of the Ordinates GC, DE, may be equal) ſuch a Point C that this may happen.

Fig. 139.

Now the Velocity in the Point C is ſuch, as will be repreſented by $\sqrt{LC}$, and the Velocity in the Point D will be $\sqrt{QD}$. Therefore $\frac{BC}{\sqrt{LC}}$ is the Time of Deſcent along BC, and $\frac{CD}{\sqrt{QD}}$ is the Time of Deſcent along CD; (by *Prop.* 54. *p.* 158. of *Newton.*) Therefore the Point C muſt be ſuch, that $\frac{BC}{\sqrt{LC}} + \frac{CD}{\sqrt{QD}} = Minim.$ Suppoſe B and D to be fixt, and make the conſtant Lines $GC = DE = m$, $LC = b$, $QD = p$; the indeterminate Lines $BG = u$, $CE = z$; whence $\sqrt{\frac{m^2+u^2}{b}} + \sqrt{\frac{m^2+z^2}{p}} = Min.$ Therefore $\frac{u\dot{u}}{b^{\frac{1}{2}}\sqrt{m^2+u^2}} + \frac{z\dot{z}}{p^{\frac{1}{2}}\sqrt{m^2+z^2}} = 0$. But $\dot{u} = -\dot{z}$, becauſe $u + z$ is equal to a conſtant Quantity. Therefore $\frac{u}{b^{\frac{1}{2}}\sqrt{m^2+u^2}} = \frac{z}{p^{\frac{1}{2}}\sqrt{m^2+z^2}}$; whence it appears that $\frac{u}{b^{\frac{1}{2}}\sqrt{m^2+u^2}}$ is equal to a conſtant Quantity. Now make the Abſciſs $AL = x$, the Ordinate $LG = y$, and therefore $BG = \dot{x}$, $GC = \dot{y}$, $BC = \sqrt{\dot{x}^2 + \dot{y}^2}$, and let a be any conſtant Line. Then it will be $\frac{\dot{x}}{y^{\frac{1}{2}}\sqrt{\dot{x}^2+\dot{y}^2}} = \frac{1}{\sqrt{a}}$; whence $\dot{x}\sqrt{a} = \sqrt{y} \times \sqrt{\dot{x}^2+\dot{y}^2}$. But in every Curve 'tis $\dot{x} . \sqrt{\dot{x}^2+\dot{y}^2}$ :: Subtangent . Tangent. Therefore the Nature of the Curve required is ſuch, that the Subtangent is to the Tangent as $\sqrt{a}$ to $\sqrt{y}$. But all know that this is a Property of the Cycloid, who know that the Tangent of the Cycloid is parallel to the Chord of the conterminate Arch in the generating Circle, whoſe Diameter is a, and whoſe Vertex points downwards.

And with the ſame Facility we may find the Curve of ſwifteſt Deſcent, in any other Hypotheſis of Gravity.

III. To find a Curve which a falling Body would deſcribe in the ſhorteſt Time, being urged by a Centripetal Force tending to a given Point;

By Mr. J. Machin, n. 358. p. 860.

Point; which Force increaſes or decreaſes according to any Power of the Diſtance from the Center; when the loweſt Point of the Curve is given, and the Altitude in the Beginning of the Fall.

Let the Center of Force be C, from which Center, with the Diſtance $C B$ equal to the Altitude from whence the Body falls, let a Circle $B E G$ be deſcribed, and let the Angle $B C G$ be a right Angle. Let A be the loweſt Point of the Curve, where it meets the Axis $C B$ at the given Diſtance $C A$. 'Tis required to find a Point Q, where the Curve of quickeſt Deſcent $E Q A$ meets the Circle $Q F$ at another given Diſtance $C F$. This Problem has two Caſes, one of which depends on the Hyperbola and Circle, the other on the Ellipſis and Circle.

Fig. 140. *Caſ.* 1. If the Centripetal Force be reciprocally as the Diſtance from the Center, let $K L M$ be any rectangular Hyperbola, deſcribed with Center C and Aſymptote $C B$, which meets the Perpendiculars $B K$, $A M$, erected upon $B C$, in the Points K, M; but any intermediate Ordinate $F L$, erected at F, in the Point L. Let it be $C D$ to $C G$ as $\sqrt{A F L M}$ to $\sqrt{A B K M}$, and let $D H$ be perpendicular to $C G$. Then let the Sector $R C B$ be taken to the Area $H D C B$, as the given Hyperbolical Area $A B K M$ to the given Rectangle $C A \times A M$. Then the right Line $R C$ will meet the Circle $F Q$ in the Point Q, which will be in the Curve of ſwifteſt Deſcent $E Q A$.

Now the Point E may be had, from whence the Fall of the Body ſhould begin, by taking the Sector $B C E$ to the Area of the Quadrant $B C G$, in the ſame Ratio as is the Hyperbolic Area $A B K M$, to the Rectangle contained under $C A$ and $A M$.

Corol. Hence if the right Line $R C$, revolving about the Center C, makes the Sectors $R C B$ proportional to the Areas $H D C B$, in which the Squares of the Baſes $C D$ are taken in Arithmetical Progreſſion; then the right Lines $C R$ will interſect the Curve $E Q A$ at Diſtances from the Center $C Q$, which will decreaſe in Geometrical Progreſſion.

Caſ. 2. Now if the Centripetal Force ſhould be reciprocally as any other Power of the Diſtance from the Center, let $n + 1$ be the Index of that Power, (where n may be any Number Integer or Fraction, affirmative or negative) and let $H = C B$ be the greateſt Altitude of the Curve required $E Q A$, $b = C A$ be the leaſt Altitude of the ſame, and $A = C F$ be any other intermediate Altitude.

In the right Line $C G$ let there be taken $C D$ to $C B$ as $\sqrt{b^n}$ to $\sqrt{H^n}$, and alſo $C H$ to $C D$ as $\sqrt{A^n - b^n}$ to $\sqrt{H^n - b^n}$. Then Center C,

Fig. 141.

and with the Semiaxes $C D$, $C B$, let the Ellipſis $B L D$ de deſcribed, which let the Ordinate $H L$ meet in L. And draw the right Line $L K$, touching the Ellipſis in L, and meeting the leſſer Axis $C D$ produced in K. Then draw $N M$ parallel to the Tangent $K L$, touching the Circle $B E M G$ in M, and meeting $C D$ in N. Laſtly, take the Sector $R C B$, which may be to the Area $N M B$, $L K N$, comprehended between the Circle and Ellipſis and the Tangents of each and the right Line $N K$, in the Ratio of the Number 2 to the Number n. Then the right Line $R C$ will interſect the Circle *FQ* in the Point *Q*, which will be in the Curve of the quickeſt Deſcent *EQA*.

Now if the Sector *BCE* be to the Area *BDG*, intercepted between the Quadrants of the Ellipſis and Circle, in the aforeſaid Ratio of 2 to n, that is, the Points *L*, *D*, as alſo *M*, *G*, coinciding (becauſe of $A^n = H^n$) the Point *E* will be that from whence the Fall of the Body ſhould begin which deſcends to *A* in the ſhorteſt Time, and which by its Motion deſcribes the Curve *EQA*, which the right Line *CE* touches in *E*, and which *CB* cuts at right Angles in *A*.

The Demonſtrations of theſe Conſtructions, which are derived from the Quadratures of the celebrated *Newton*, and from his Principles of natural Philoſophy, (*Prop.* 39, *&c.*) ſhall be given on ſome other Occaſion. Now it is a Problem of another Kind, to deſcribe Curves through which Bodies would move from the higheſt Point *E*, which is the Beginning of the Fall, with the ſwifteſt Deſcent to lower Points *Q* which are given, when urged by any centripetal Force; the Solution of which Problem I have in my Power. At preſent it may ſuffice to have given a general Idea of theſe Curves, and to ſhew their Relation to the Quadratures of the Circle and Hyperbola, without which it will hardly be very eaſy to conſtruct them Geometrically.

The Laws of Attraction, &c. by Dr. John Keill, n. 315. p. 97.

IV. We muſt lay down theſe three Principles as a Foundation, on which the whole Science of Phyſicks is to be built. 1. That there is a *Vacuum*, or empty Space. 2. That Quantity is diviſible *in infinitum*. 3. That Matter has an attractive Force: That there is a *Vacuum* is evident from the Motion of Bodies: From the Nature of continued Quantity, Geometricians have demonſtrated the infinite Diviſibility of Matter: And Experience informs us, that Matter has an attractive Force. Now from the two firſt Principles it follows:

Theor. 1. That any the ſmalleſt Particle of Matter may ſo occupy any Space tho' ever ſo large, that the Diameters of all the Pores or Interſtices ſhall be leſs than any given right Line, or that all the Particles ſhall be at a Diſtance from one another, which ſhall be leſs than any given Interval.

Theor. 2. Two Bodies may be given equal in Bulk, but as unequal as you pleaſe in Weight or Denſity, (that is, in Quantity of Matter) in which the Aggregates of the Pores or Interſtices ſhall be nearly equal.

For Inſtance, let there be a cubical Inch of Gold, and another of Air; tho' the Matter in the Cube of Gold be 20000 Times more than the Matter in the Cube of Air; yet it may be ſo order'd, that the empty Spaces in the cubick Inch of Gold ſhall be nearly equal to the empty Spaces in the cubick Inch of Air: That is, that the Vacuities in the Gold ſhall be to the Vacuities in the Air, as 999999 is to 1000000.

Theor. 3. The Particles which conſtitute Water, or Air, or any other ſuch Fluid, (if they touch one another) are not abſolutely ſolid, but are compoſed of other Particles, containing many Pores and Interſtices within themſelves.

The leaſt Particles of Bodies being abſolutely ſolid, that is without any *Vacuum*, ay be call'd Particles of the firſt Compoſition. Little Parts ariſing from ſeveral f theſe Particles growing together may be call'd Particles of the ſecond Compoſiion. Lumps of theſe made by ſeveral of theſe Parts compounded together may e call'd Particles of the third Compoſition; and ſo on, till we at laſt arrive at

Particles, of which the laſt Compoſition of Bodies is made, and into which they are reſolved again by their firſt Reſolution.

That there is an attractive Force in Matter, by which every Particle of Matter attracts to itſelf every other Particle of Matter, and is mutually attracted, was firſt diſcover'd by Sir *Iſaac Newton* from obſerving the *Phænomena*. In a given Parcel of Matter this Force is, at different Diſtances, reciprocally proportional to the Squares of thoſe Diſtances. From hence ariſes that Force which we call Gravity, by which all Terreſtrial Bodies are urged directly towards the Earth, and is the Weight of Bodies always proportional to the Quantity of their Matter. By extending this attractive Force of Matter, of which he was the firſt Diſcoverer, he has moſt beautifully explain'd all the Motions of the Planets, and the Appearances of Comets.

After frequently revolving in my Mind the Divine Diſcoveries of this moſt ſagacious Man, I fell at laſt upon this Thought, that a certain Principle might be apply'd, not unlike to this of *Newton*'s, to the Explaining of the Terreſtrial *Phænomena*. After Experiments often repeated, I perceived there was a certain attractive Force in terreſtrial Matter; from whence the Reaſon of many *Phænomena* is to be derived. And theſe Thoughts of mine about five Years ago I open'd to Mr. *Newton*, and I underſtood from him, that he had long ago obſerved the ſame Things that I had found. Mr. *Newton* propoſed ſome Queries relating to this attractive Force, at the End of his *Opticks*, publiſhed in *Latin* about two Years ago. Now as it cannot be expected that that great Man ſhould proceed ſtill to improve theſe Studies, both by reaſon of his Age and other Buſineſs; I thought it would not be amiſs if I ſhould purſue his Steps herein, tho' at a great Diſtance from him. At preſent I ſhall barely propoſe ſome *Theorems*, which I may hereafter farther enlarge upon, and give their Demonſtrations in a juſt Volume.

Theor. 4. Beſides that attractive Force, by which the Bodies of the Planets and Comets are retain'd in their proper Orbits, there is alſo another Power in Matter, by which the ſeveral Particles of which they are compoſed attract one another, and are mutually attracted. Which Power decreaſes in a greater than a duplicate Ratio of the increaſing Diſtance.

This *Theorem* may be proved by a Multitude of Experiments. But the Ratio in which this Power is diminiſh'd, when the Particles recede from one another, whether it be a triplicate, quadruplicate, or any other Ratio of the increaſing Diſtances, which is greater than the Duplicate, cannot ſo well be known by Experiment. Yet perhaps a Time will come, when by a more accurate and diligent Enquiry it may be diſcover'd.

Theor. 5. If a Body conſiſts of Particles, each of which is endued with an attractive Force decreaſing in a triplicate, or more than a triplicate Ratio of the Diſtances; the Force by which a Corpuſcle is urged by that Body, in Contact itſelf, or at an infinitely ſmall Diſtance from Contact, will be infinitely greater, than if that Corpuſcle were placed at a given Diſtance from the ſame Body.

See *Prop.* 80, and 91, of *Newton*'s Principles.

Theor. 6. The ſame Things being ſuppoſed, if that attractive Force at an aſſignable Diſtance has a finite Ratio to Gravity, the ſame will be infinitely greater than the Force of Gravity in Contact, or at an infinitely ſmall Diſtance.

Theor. 7. But if in Contact the attractive Force of the Bodies has a finite Ratio to Gravity, the ſame at every aſſignable Diſtance is infinitely leſs than the Force of Gravity, and will therefore vaniſh.

Theor. 8. The attractive Force wherewith all the Particles of Matter are endued in Contact, exceeds the Force of Gravity almoſt immenſely; yet is not infinitely greater than the Force of Gravity; therefore in a given Diſtance that Force will vaniſh.

Therefore this Force being ſuperadded to Matter, is only diffuſed thro' Spaces that are vaſtly little. At greater Diſtances it is nothing at all. Therefore the Motions of the Heavenly Bodies, which are ſeparated from one another at very great Diſtances, will not at all be diſturbed by this attractive Force, but will continually perform their Courſes in the ſame Manner, as if Bodies had no ſuch Force.

Theor. 9. If any Corpuſcle touch a Body, the Force by which that Corpuſcle will be urged, that is, the Force by which it adheres to the Body, will be proportional to the Quantity of Contact. For the Parts that are any Thing remote from the Contact will contribute nothing to the Coherence.

Therefore various Degrees of Coherence will ariſe according to the various Contact of the Particles. But thoſe Forces of Coherence will be greateſt of all, when the Superficies are plain by which the Bodies touch one another. In which Caſe, when other Things are alike, the Force by which a Corpuſcle coheres with others, will be as the Parts of the Superficies that touch one another.

Hence appears the Reaſon, why two Marble-ſtones that are exactly poliſhed, and touching one another according to plain Superficies, cannot be pull'd directly from each other, unleſs by a Weight that much exceeds the Gravity of the incumbent Air.

Hence may be derived a Solution of that moſt celebrated Problem, concerning the Coheſion of Matter.

Theor. 10. Thoſe Corpuſcles are moſt eaſily ſeparated from one another, the Contacts of which with others are the feweſt and the leaſt. Such are the Contacts of Globular Corpuſcles that are of an infinitely little Magnitude.

Hence is given the Reaſon of Fluidity.

Theor. 11. The Force by which any Corpuſcle is attracted to another Body which is very near it, does not change its Quantity, whether the Matter of the attracting Body is increaſed or diminiſhed, the Denſity of the Body remaining the ſame, and alſo the Diſtance of the Corpuſcle.

For ſince the attracting Forces of the Particles are diffuſed only through very ſmall Spaces; it is plain that the remoter Parts at *C*, *D*, and *E*, contribute nothing Fig. 142. to the Attraction of the Corpuſcle *A*. Therefore the Corpuſcle will be attracted towards *B* with the ſame Force, whether theſe Parts are preſent or not, or others are annexed to them.

Theor. 12. If the Texture of any Body be ſuch, that Particles of the laſt Compoſition are a little removed from their original Contact by any external Force, ſuch is a Weight compreſſing them, or a Blow proceeding from another Body, nor do they paſs into new Contacts; the Particles mutually approaching by the attractive Force will ſoon return to their original Contacts. But the ſame Contacts and Poſitions returning of the Particles that compoſe any Body, the ſame Figure alſo of the Body will return; and therefore by the attractive Force Bodies may again recover their former Figures which they have loſt.

Hence a Reaſon may be given for Elaſticity. For whereas Bodies impinging againſt each other, by their elaſtic Force mutually rebound from one another; from the attractive Force of Bodies, (as is demonſtrated in my Phyſical Lectures) a Reſilition from one another ought thence to ariſe.

Theor. 13. Now if the Texture of a Body be ſuch, that the Particles being removed from their former Contacts by an impreſſed Force immediately come into others which are of the ſame Degree, that Body will not reſtore itſelf to its former Figure.

Hence it may be underſtood, of what Texture ſoft Bodies ſhould be, or in what the Softneſs of Bodies conſiſts.

Theor. 14. The Particles of Matter may be endued with different attractive Forces, according to their different Structure and Compoſition; the Attraction for Inſtance will not be ſo ſtrong when a Particle of a given Magnitude is perforated with ſeveral Pores and Paſſages, as If it were entirely ſolid and without any Vacuity.

Theor. 15. The attractive Forces of perfectly ſolid Particles very much depend upon their Figures.

For if any ſmall Particle of Matter were form'd into a circular Plate of an indefinitely ſmall Thickneſs, and a Corpuſcle were placed in the right Line paſſing through the Center, and were put at a Plain of a perpendicular Circle, and the Diſtance of the Corpuſcle was equal to to a tenth Part of the Semidiameter of the Circle; the Force by which the Corpuſcle is urged will be thirty Times leſs than if the attracting Matter ſhould put on the Form of a Sphere, and the Virtue of the whole Particle were diffuſed as it were from one Phyſical Point. Alſo the ſame circular Plate would attract a Corpuſcle more ſtrongly to itſelf than another Particle of the ſame Weight, which ſhould be formed into a thin and long Cylinder.

Theor. 16. Salts are Bodies whoſe Particles of the laſt Compoſition are endued with a great attractive Force, among which Particles however many Vacuities are interſperſed, which are pervious to the Particles of Water of the laſt Compoſition: Which therefore being ſtrongly attracted by the ſaline Particles, ruſh upon them with Violence, and disjoin them from their mutual Contact, and diſſolve the Coherence of the Salts.

Theor. 17. If two Corpuſcles mutually approach to each other, with attractive Forces decreaſing in a triplicate or more than triplicate Ratio of their Diſtances; their Velocity when they impinge upon one another will be infinitely greater than when they are at a given Diſtance from one another. *See* Newt. *Prin. Pr.* 39.

Theor. 18. The Magnitude of a Body which is heavier than Water may be ſo far diminiſh'd, that at laſt it may float ſuſpended in the Water, and not deſcend by vertue of its Gravity.

Hence appears the Reaſon, why the Particles of Salt, Metal, and others of the like Kind, being reduced to the ſmalleſt Particles, hang as it were ſuſpended in their proper *Menſtrua*.

Theor. 19. Greater Bodies approach to one another with leſs Velocity than leſſer Bodies.

Fig. 143, 144. For the Force by which the Bodies *A* and *B* approach to one another, belongs only to the Particles that are neareſt; for the more remote have no Force at all.

Therefore [illegible] greater Force is not applied to the moving of the Bodies *A* and *B*, than to the moving of the Particles *c* and *d*. But the Velocities of Bodies that are moved with the ſame Force, are reciprocally proportional to thoſe Bodies. Whence the Velocity with which the Body *A* tends towards *B*, will be to the Velocity with which the Particle *c*, not connected with the Body, would tend towards the ſame *B*, as the Particle *c* to the Body *A*. Therefore the Velocity of the Body *A* is much leſs than the Velocity of the Particle *c* would be, if at Liberty from the Body.

Hence it comes to paſs, that the Motion of the greater Bodies is ſo ſlow and languid of its own Nature, that it is commonly hinder'd by an ambient Fluid, and other Bodies that are round about it. But in the ſmaller Corpuſcles the Virtue is vigorous, and very many Effects are produced by them. So much is the Energy greater in the ſmaller Bodies, than in the greater.

Hence appears the Reaſon of that Chemical Axiom, that Salts do not act but when in Solution.

Theor. 20. Two Corpuſcles not touching one another may be placed ſo near, that the Force by which they affect one another, may much exceed the Force of Gravity.

Theor. 21. If a Corpuſcle placed in a Fluid is equally attracted on all Sides by the ſurrounding Particles, no Motion will thence ariſe to the Corpuſcle. But if it be urged more by ſome Particles, and leſs by others, the Corpuſcle will tend that Way where the greateſt Attraction is. And the Motion produced will anſwer the Inequality of Attraction, or in a greater Inequality the Motion will be greater, but leſs in a leſſer Inequality.

Theor. 22. Corpuſcles floating in a Fluid, and attracting one another more than the intermediate Particles of the Fluid; having diſpel'd the Particles of the Fluid they will approach to one another with that Force, by which their mutual Attraction exceeds the Attraction of the Particles of the Fluid.

Theor. 23. If any Body is placed in a Fluid, whoſe Parts more attract the Particles of the Fluid, than the Particles of the Fluid are attracted by one another; and if in the Body there are many Paſſages and Pores that are pervious to the Particles of the Fluid; that Fluid will ſoon diffuſe itſelf thro' theſe Interſtices. And if the Connexion of the Parts of the Body is not ſo firm, but that it may be overcome by the Violence of the ruſhing Particles, a Diſſolution of the immerged Body will thence ariſe.

Hence three Things are required, that a *Menſtruum* may be fit for diſſolving a given Body. 1. That the Parts of the Body may more attract the Particles of the *Menſtruum*, than they are attracted by one another. 2. That the Body may have Pores and Interſtices open and pervious to the *Menſtruum*. 3. That the Coherence of the Particles conſtituting the Body may not be ſo great, but that it may be overcome by the Violence of the ruſhing Particles of the *Menſtruum*. Hence it is alſo plain, that the conſtituent Particles of Spirit of Wine are more attracted by one another, than by the Particles of a ſaline Body immerſed in Spirit of Wine.

Theor. 24. If the Corpuſcles floating in a Fluid, and attracting one another, are Elaſtic, after Congreſs they will rebound from one another. And then other Corpuſcles impinging again, will be again reflected. From whence there will be innumerable Conflicts with other Corpuſcles, and continual Reboundings. But by the attractive Force the Velocity of the Corpuſcles will continually increaſe, and the inteſtine Motion of the Parts will be apparent even to Senſe.

Now as the Corpuſcles may attract one another either more ſtron[illegible] or m weakly, according to the different Elaſticity they are endued with, theſe M tions will be various, and will become ſenſible in different Degrees and at di ferent Times.

Theor. 25. If Corpuſcles that attract touch one another, no Motion will ariſe; f they cannot come nearer than Contact. If they are ſeparated from one anoth at a very ſmall Diſtance, a Motion will ariſe. But if they are farther from o another, they will not attract one another with a greater Force than the int mediate Particles of the Fluid, and ſo no Motion will be produced.

On theſe Principles depend all the *Phænomena* of Fermentation and Effervefcen Hence the Reaſon appears, why Oyl of Vitriol ferments and bubbles, by the Inf ſion of a little Water. For the ſaline Corpuſcles are ſomething removed from m tual Contact by the Affuſion of the Water; and as they attract one another mo forcibly than the Particles of Water, and as they are not equally attracted on a Sides, a Motion muſt thence neceſſarily ariſe.

Hence alſo the Reaſon appears, why ſo great an Ebullition is produced, when F lings of Steel are ſuperadded to the foreſaid Mixture. For the Particles of St are endued with a great Elaſticity, whence a ſtrong Reflexion ariſes. And henc we may ſee, why certain *Menſtrua* act with a greater Force, and diſſolve any Bod ſooner, if they are ſomething diluted with Water.

Theor. 26. If Corpuſcles that attract one another are without any Elaſtic Forc they will not rebound from one another, but will compoſe Lumps or Co geries of their Particles. Hence a *Coagulum* or Curdling is produced. An if the Gravity of the accumulated Particles exceeds the Gravity of the Fluid, Precipitation or Subſiding will ſucceed. Alſo a Precipitation may ariſe fro the Gravity of the *Menſtruum* being either increaſed or diminiſh'd, in which t Corpuſcles floated.

Theor. 27. If the Figures of the attracting Corpuſcles, and thus floating in a Fluid be ſuch, as that in ſome of their given Parts they are endued with a greater attractive Force than in others, and alſo a greater Contact is in the ſame, thoſe Corpuſcles will go together into Bodies having given Figures, whence Chryſtallizations will be produced. And the Figures of the compounding Corpuſcles may be determin'd by Geometry, from the Figure of the Chryſtal being given.

Theor. 28. If the Corpuſcles are more attracted by the Particles of the Fluid than by one another; they will be made to recede as if they fled from one another, and they will ſoon be diffuſed through all the Fluid.

Theor. 29. If any Corpuſcle intervenes between two Particles of a Fluid, the tw oppoſite Faces of which are endued with very great attractive Forces; this intervening Corpuſcle will conjoin the Particles of the Fluid to one another; an many Corpuſcles of this Kind diſperſed through the Fluid will fix all the Pa ticles into a firm Body, or will reduce the Fluid into ſolid Ice.

Theor. 30. If any Body ſhould emit a very great Plenty of *Effluvia*, the attractive Forces of which are very ſtrong; when theſe *Effluvia* approach to any light Body, their attractive Virtues will at laſt overcome the Gravity of the lighter Body; and the *Effluvia* will attract that Body upwards to themſelves; and as the *Effluvia* are much more denſe in leſſer Diſtances from the emitting Body than in greater, the light Body will always be urged towards the denſer *Effluvia*, till at laſt it adheres to the Body itſelf that emits the *Effluvia.* Hence many of the *Phenomena* of Electricity may be explained.

Perhaps it may be objected againſt this Doctrine of ours concerning attractive Forces, that if this Power of Attraction was in all Matter of every Kind, the more ponderous Bodies having more Matter within a given Space ought to attract moſt, or more than lighter Bodies, which is contrary to Experience. But this Objection may eaſily be anſwer'd. For Particles of the laſt Compoſition, (to which only the attractive Virtue is imputed) being placed very thick near one another, may make a Body ponderous, tho' they may be more rare among themſelves than thoſe Particles, which conſtitute a light Body of the laſt Compoſition, being more remote from one another, and having more and wider Vacancies.

There are many other *Phenomena* of Nature, which ſeem to me capable of being explain'd from the ſame Principles; as the Aſcent of the Sap in Plants and Trees, the conſtant and determinate Figures of Leaves and Flowers, and their ſpecifick Virtues, *&c.* And many Things alſo, which daily occur in the Animal Body, eſpecially which have a Relation to the Motion of the Fluids and the Secretions, and depend on the ſame Properties of Matter; and hence the Theories of Diſeaſes and the Effects of Medicines may be eaſily derived.

The Laws of the Centripetal Force, *by Dr.* John Keill, n. 317. p. 174.

V. The learned Dr. *Halley* communicated a Theorem to me, by which the Law of the Centripetal Force may be exhibited in finite Quantities, which was ſhew'd him by M. *de Moivre*, who ſaid that Sir *Iſaac Newton* had before found a Theorem which was like this. Now as the Demonſtration of this Theorem is very eaſy, I had a Mind to communicate it to the Publick, with ſome other Thoughts on the ſame Subjects.

Theorem. *If a Body moves in any Curve by Means of a Centripetal Force tending to any Center; in every Point of the Curve that Force will be in a Ratio compounded of the direct Ratio of the Diſtance of the Body from the Center of Force, and the reciprocal Ratio of the Cube of a Perpendicular let fall from the Center upon the right Line touching the Curve in the ſame Point, drawn into the Radius of Curvature belonging to the ſame Point.*

Fig. 145.

Demonſtration. Let QAO be any Curve, which is deſcribed by the Motion of a Body, attracted by a Centripetal Force tending to the Point S. And let AO be an Arch which is deſcribed in any the leaſt Time, P*m* its Tangent, AR the Radius of a Circle of equal Curvature, that is, the leaſt Part of whoſe Periphery coincides with the Arch AO. And let SP be a right Line falling perpendicularly from the Point S upon the Tangent. Draw O*m* and O*n* parallel to SA and SP. And let O*m* denote the Force by which the Body in A is urged towards S. The Force by which Body recedes perpendicularly from the Tangent will be as O*n*; that is, the Force tending towards R, and cauſing the Body, moving with the ſame Velocity as before, to deſcribe a Circle equicurved to the Arch AO, will be to the Force tending towards S, by which the Body moves in the Curve AO, as O*n* to O*m*, or becauſe of equiangled Triangles, as SP to SA. But the Centripetal Forces of Bodies moving in Circles are as the Squares of the Velocities applied to the Radii, by Cor. of Theor. 4. of *Newton*'s Principles. But the Velocity is reciprocally as SP, or directly as $\frac{1}{SP}$ and therefore the Square of the Velocity will be as $\frac{1}{SP{\cdot}q}$. Therefore the Force at O*n*, or the Force with which the Body could move in an equicurved Circle, will be as $\frac{1}{SPq \times AR}$. Now it has been ſhewn, that i is SP to SA, ſo is the Force tending towards R, by which the Body may move i an equicurved Circle, to the Force tending towards S. But the Force tending towards R is as $\frac{1}{SPq \times AR}$, and therefore ſince it is SP . SA : : $\frac{1}{SPq \times AR}$. $\frac{SA}{SPc \times AR}$, the Force tending toward S, will be as $\frac{SA}{SPc \times AR}$. *Q. E. D.*

Fig. 146. *Corol.* If the Curve QAO is a Circle, the Centripetal Force tending towards S will be as $\frac{SA}{SPc}$. And therefore if the Centripetal Force tends towards S a Point ſituate in the Circumference, it will be (by 32 of the Third) Ang. PAS = AQS; and therefore becauſe of ſimilar Triangles ASP, ASQ, it will be AQ . AS : : AS . SP, whence $SP = \frac{ASq}{AQ}$, and $SPc = \frac{AScc}{AQc}$, whence $\frac{SA}{SPc} = \frac{SA \times AQc}{AScc} = \frac{AQc}{ASqc}$, that is, becauſe of AQ being given, the Force will be reciprocally as ASqc.

Fig. 147. Let DAB be an Ellipſis, whoſe Axis is DB, and Foci F and S, AR, OR, two Perpendiculars to the Curve very near each other. Draw KL, OT, perpendicular to SA, and KM perpendicular to OR. Becauſe 'tis SA . SK : : FA + SA . FS, (by *Prop.* 3. *El.* 6.) that is, in a given Ratio, the Fluxions of SA, SK, that is, AT, K*k*, will be proportional to SA, SK. And it is (by *Propoſition* 6. of Part 4. of *Milns*'s Conic Sections) AL = ½ the Latus Rectum = ½ L. Moreover becauſe of KA parallel to SP, 'tis Ang. ASP = KAL = TOA, becauſe the Angle TAO is the Complement of each to a right Angle. Wherefore KA . AL : : SA . SP, whence $SP = \frac{L}{2} \times \frac{SA}{KA}$, and $KA = \frac{L \times SA}{2\,SP}$. Again, becauſe of equiangled Triangles KM*k*, GPS, and OTA, SPA.

It is KM . K*k* : : GP . GS : : AP . SK,
Alſo K*k* . AT : : SK . SA,
Alſo AT . AO : : AP . SA,

It will be KM . AO : : APq . SAq : : SAq — SPq . SAq : : $SAq - \frac{Lq \times SAq}{4\,AKq}$. SAq : : 4 AKq — Lq . 4 AKq. Whence Lq . 4 AKq : : (AO—KM . AO : :) AK . AR; and therefore $AR = \frac{4\,AKq}{Lq}$. And by the ſame Way of Reaſoning in the Hyperbola, the Radius of Curvature will be found $\frac{4\,AKq}{Lq} = \frac{L \times SAc}{2\,SPc}$.

Fig. 148. But in the Parabola the Calculation will be eaſier. For becauſe of the Subnormal being given, 'tis always K*k* = AT equal to the Fluxion of the Axis: and the Triangles K*k*M, ATO, SPA, ALK, are equiangular, whence KM . K*k* : : AP . SA; alſo it is AT (K*k*) . AO : : AP . SA, whence KM . AO : : APq . SAq : : SAq — SPq . SAq, whence it will be SPq . SAq : : AO — KM . AO : : KA . AR, and therefore $AR = \frac{SAq \times AK}{SPq}$. But AL = ½ the Latus Rectum =½

$= \frac{1}{2} L$, and $AK . AL :: SA . SP$; wherefore it will be $\frac{L}{2} \times \frac{SA}{AK} = SP$, and $SPq = \frac{Lq \times SAq}{4AKq}$. Therefore it is $AR = \frac{4AKc}{Lq}$, or becauſe it is $AK = \frac{L \times SA}{2SP}$, it will be $AR = \frac{L \times SAc}{2SPc}$.

Fig. 149.

And hence ariſes a moſt eaſy Conſtruction, for determining the Radius of Curvature in any Conic Section. For let A K be perpendicular to the Section meeting the Axis in K; from K upon A K let the Perpendicular H K be erected, meeting A S produced in H. From H let H R be erected perpendicular upon A H, and A R will be the Radius of Curvature. In the Parabola the Conſtruction becomes ſtill ſomething more ſimple. For becauſe by the Nature of the Parabola 'tis $SA = SK$, and the Angle A K H is a right one, S will be the Center of a Circle paſſing through A K H. Whence the Radius of Curvature is found by producing S A to H, that $SH = SA$, and at H erecting the Perpendicular H R. Then R will be the Center of the Circle that coincides moſt intimately with the Parabola in A.

The Centripetal Force tending to the Focus of the Conic Section, in which the Body moves, is reciprocally proportional to the Square of the Diſtance. For becauſe $AR = \frac{L \times SAc}{2SPc}$ it will be $\frac{AR}{SPc \times AR} = \frac{SA \times 2SPc}{SPc \times L \times SAc} = \frac{2}{L \times SAq}$. That is, becauſe of $\frac{2}{L}$ being given, the Centripetal Force will be as $\frac{1}{SAq}$.

Fig. 150.

Let B A D be an Ellipſis, which the right Line G E touches in A. And let S P paſſing through the Center of the Ellipſis, and K A paſſing through the Point of Contact, be both perpendicular to the Tangent. $SP \times KA$ will be equal to a fourth Part of the Figure of the Axis, or it will be equal to the Square of the leſſer Semiaxis, $= BO \times DE$. For becauſe of equiangular Triangles G B O, G L A, G A K, G P S, and G D E,

$$
\begin{array}{lll}
SP . SG :: & & BO . GO. \\
SG . DG :: & BG . LG :: & GO . GA. \\
DG . DE :: & & GA . AK.
\end{array}
$$

Whence $SP . DE :: BO . AK$, and $SP \times AK = DE \times BO = \frac{1}{4} L \times SB$.

Hence if a Body moves in an Ellipſis with a Centripetal Force tending to the Center of the Ellipſis, that Force will be directly as the Diſtance. For it is $\frac{SPc \times 4AKc}{Lq}$, = to a given Quantity, becauſe $SP \times AK$ is a given Quantity. Therefore a Force as $\frac{SA}{SPc \times AR}$ will be as the Diſtance S A.

Fig. 147.

In Fig. 147. from the other Focus F letting fall a Perpendicular F I upon the Tangent; becauſe of ſimilar Triangles S A P, F A I, it will be

$SA . SP :: FA . FI = \frac{SP \times FA}{SA}$. Whence it will be $SP \times FI = \frac{SPq \times FA}{SA}$ equal to the Square of the leſſer Semiaxis. Whence if the greater Axis be call'd b, and the leſſer $2d$, it will be $SPq = \frac{dd \times SA}{b - SA}$, and $SP = \frac{d \times \sqrt{SA}}{\sqrt{b - SA}}$.

But in the Hyperbola it is $SP = \frac{d \times \sqrt{SA}}{\sqrt{b + SA}}$.

In the Parabola it is $SP = \sqrt{d \times SA}$, ſuppoſing its Latus rectum $4d$. Becauſe it is $TAq . TOq :: APq . SPq :: SAq - SPq . SPq :: SAq - \frac{ddSA}{b - SA} . \frac{ddSA}{b - SA} :: SA - \frac{dd}{b - SA} . \frac{dd}{b - SA} :: bSA - SAq - dd . dd$, it will be $\sqrt{bSA - SAq - dd} . d :: TA . TO$. And as it is $TA = S\dot{A}$, it will be $TO = \frac{dS\dot{A}}{\sqrt{bSA - SAq - dd}}$.

Now let Q A O be any Curve, one of whoſe leaſt Arches is A O, the Tangents in the Points A and O are A P and Op, the Radius of Curvature A R, and Perpendiculars upon the Tangents are S P and S p. It will be $\frac{SA \times TA}{fP} = AR$. For becauſe of ſimilar Triangles it is $fP . AO :: PA . RA$. And $AO . TA :: SA . PA$; whence *ex æquo* it will be $fP : TA$ or $S\dot{A} :: SA . RA$. But it is $fP = S\dot{P}$; wherefore it will be $RA = \frac{SA \times S\dot{A}}{S\dot{P}}$.

Fig. 151.

Hence if the Diſtance S A be drawn into its Fluxion, and divided by the Fluxion of the Perpendicular, we ſhall have the Radius of Curvature. By which Theorem the Curvature is eaſily determined in Radial Curves or Spirals. For Example. Let A Q be the Nautical Spiral; becauſe the Angle S A P is given, alſo the Ratio of S A to S P will be given. Let that Ratio be a to b. Then it will be $SP = \frac{bSA}{a}$, and $S\dot{P} = \frac{bS\dot{A}}{a}$, and $AR = \frac{SA \times S\dot{A}}{S\dot{P}} = \frac{aSA}{b}$. Whence it plainly appears, that the Evolute of the Nautical Spiral is the ſame Spiral in another Poſition.

Becauſe $AR = \frac{SA \times S\dot{A}}{S\dot{P}}$, it will be $\frac{SA}{SPc \times AR} = \frac{S\dot{P}}{SPc \times S\dot{A}}$.

And from hence again from the given Relation of S A and S P, the Law of the Centripetal Force will eaſily be found.

Example. Let V A B be an Ellipſis whoſe Focus is S, the greater Axis V B = b, the leſſer Axis 2 d, the Latus rectum 2 R. And let VaQ be another Curve ſo related to this, that the Angle V S A may be always proportional to the Angle V S a, and let S a = S A. The Law of the Centripetal Force tending to S is required, by which the Body may move in the Curve V a Q. Fig. 152.

Becauſe the Angle V S A is to V S a in a given Ratio; the cotemporary Increments of theſe Angles will be in the ſame Ratio, and let this be the Ratio of m to n. Whence it will be $ot = \frac{n \times OT}{m}$. But it is $OT = \frac{d\,\dot{SA}}{\sqrt{b\,SA - SAq - dd}}$; whence $ot = \frac{n\,d\,\dot{SA}}{m\sqrt{b\,SA - SAq - dd}}$.

Now becauſe it is $SAq + SPq \,.\, SPq :: ta \times ta + ot \times ot \,.\, ot \times ot :: \dot{SA}q + \frac{n^2 d^2 \dot{SA}q}{m^2 \text{ in } b\,SA - SAq - d^2} \,.\, \frac{n^2 d^2 \dot{SA}q}{m^2 \text{ in } b\,SA - SAq - d^2} :: 1 + \frac{n^2 d^2}{m^2 \text{ in } b\,SA - SAq - dd} \,.\, \frac{n^2 d^2}{m^2 \text{ in } b\,SA - SAq - d^2} :: m^2 b\,SA - m^2\,SAq - m^2 d^2 + n^2 d^2 \,.\, n^2 d^2$. Whence it will be $\sqrt{m^2 b\,SA - m^2\,SAq - m^2 d^2 + n^2 d^2} \,.\, nd :: SA \,.\, SP$, and therefore $SP = \frac{n\,d\,SA}{\sqrt{m^2 b\,SA - m^2\,SAq - m^2 d^2 + n^2 d^2}}$. Now that the Fluxion of this may be had, for $m^2 b\,SA - m^2\,SAq - m^2 d^2 + n^2 d^2$ let x be wrote, and it will be $SP = \frac{n\,d\,SA}{\sqrt{x}}$, and $SPc = \frac{n^3 d^3\,SAc}{x^{\frac{3}{2}}}$; and then $\dot{x} = m^2 b\,\dot{SA} - 2\,m^2\,SA \times \dot{SA}$, and $\dot{SP} = n\,d\,\dot{SA} \times x^{-\frac{1}{2}} - \frac{1}{2} \times \frac{n\,d\,SA\,\dot{x}}{x^{\frac{3}{2}}}$. And reducing the Fractions to the ſame Denominator it will be $\dot{SP} = \frac{n\,d\,\dot{SA}\,x - \frac{1}{2}\,n\,d\,SA\,\dot{x}}{x^{\frac{3}{2}}}$. And in the Numerator inſtead of x and $\dot{x}$ putting their Values, and reducing to Order, it will be $\dot{SP} = \frac{n\,d\,\dot{SA} \times \frac{1}{2} m^2 b\,SA - m^2 d^2 + n^2 d^2}{x^{\frac{3}{2}}}$. Whence it will be $\frac{\dot{SP}}{SPc \times \dot{SA}} = \frac{\frac{1}{2} m^2 b\,SA - m^2 d^2 + n^2 d^2}{n^2 d^2\,SAc}$. But $\frac{\dot{SP}}{SPc \times \dot{SA}}$ is as the centripetal Force; therefore this Force will be as $\frac{\frac{1}{2} m^2 b\,SA - m^2 d^2 + n^2 d^2}{n^2 d^2\,SAc}$;

or becauſe of the given $n^2 d^2$ in the Denominator, this Force will be as $\frac{\frac{1}{2} m^2 bSA - m^2 d^2 + n^2 d^2}{SAc}$. Or inſtead of d^2 putting $\frac{bR}{2}$, the Force will be as $\frac{\frac{1}{2} m^2 bSA - \frac{1}{2} m^2 bR + \frac{1}{2} n^2 bR}{SAc}$, or becauſe of the given $\frac{b}{2}$, as $\frac{m^2 SA - Rm^2 + Rn^2}{SAc} = \frac{m^2}{SAq} + \frac{Rn^2 - Rm^2}{SAc}$. All which exactly coincide with what is deliver'd by Sir *Iſ. Newton*, in *Prop.* 44. of his *Principia*, concerning the Centripetal Force of a Body moving in the ſame Curve.

Becauſe the Centripetal Force tending to the Point S, by which a Body may move in a Curve, is always as $\frac{\dot{S}P}{SPc \times \dot{S}A}$; hence from the Law of the Centripetal Force being given, the Relation of S A and S P may be found, and therefore by the Inverſe Method of Tangents the Curve may be exhibited, which ſhall be deſcribed by a given Centripetal Force.

For Inſtance, let the Force be reciprocally as any Dignity m of the Diſtance; that is, let $\frac{\dot{S}P}{SPc \times \dot{S}A} = \frac{b}{a^2 \times SA^m}$. It will be $\frac{\dot{S}P}{SPc} = \frac{b\dot{S}A}{a^2\, SA^m}$; and taking the Fluents of theſe Fluxions, it will be $\frac{1}{2} SP^{-2} = \frac{bSA^{1-m} \mp e}{\overline{m-1} \times a^2}$. Whence it will be $\frac{\frac{m-1}{2} \times a^2}{bSA^{1-m} \mp e} = SPq$, and multiplying both the Numerator and the Denominator of the Fraction by SA^{m-1}, and inſtead of $\frac{m-1}{2} a^2$ putting d^2, it becomes $\frac{d^2\, SA^{m-1}}{b \mp eSA^{m-1}} = SPq$. Therefore $SP = \frac{d\sqrt{SA^{m-1}}}{\sqrt{b \mp eSA^{m-1}}}$.

Now if the conſtant Quantity $e = 0$, it will be $SP = \frac{d\sqrt{SA^{m-1}}}{\sqrt{b}}$.

Thus if the Force be reciprocally as the Square of the Diſtance, it may be put $SP = \frac{\sqrt{d^2\, SA}}{\sqrt{b}}$, and the Curve will be a Parabola, whoſe Latus Rectum is $\frac{4dd}{b}$. Or it may be $SP = d \times \frac{\sqrt{SA}}{\sqrt{b - SA}}$, and the Curve will be an Ellipſis. Or laſtly, it may be $SP = d \times \frac{\sqrt{SA}}{\sqrt{b + SA}}$, and the Curve becomes an Hyperbola.

If the Force is reciprocally as the Cube of the Diſtance, it may be ſuppoſed that $\mathrm{SP} = \frac{d\,\mathrm{SA}}{b}$, and the Curve becomes the Nautical Spiral. Or it may be $\mathrm{SP} = \frac{d\,\mathrm{SA}}{\sqrt{b - e\,\mathrm{SA}^2}}$, and the Curve will be the ſame as that, whoſe Conſtruction Sir *I. Newton* has derived from the Sector of the Hyperbola. Or it may be $\mathrm{SP} = \frac{d\,\mathrm{SA}}{\sqrt{b + e\,\mathrm{SA}^2}}$, the Conſtruction of which Curve *Newton* has deliver'd by the Sectors of the Ellipſis, *Cor.* 3. *Prop.* 1. *Lib.* 1. *Princip.*

If the Centripetal Force be reciprocally as the Diſtance, the Relation between S A and S P cannot be determined by an Algebraical Equation; yet the Curve may be conſtructed by the Logarithmic Line, or by the Quadrature of the Hyperbola. For it is then $\mathrm{SP} = \frac{d}{\sqrt{b - \mathrm{L.SA}}}$, where L . S A denotes the Logarithm of S A.

All theſe Things follow from the now ſo much celebrated Method of Fluxions, of which Sir *Iſaac Newton*, without any Doubt, was the firſt Inventer, as will eaſily be evident to any one, that ſhall read thoſe Epiſtles of his, which were firſt publiſhed by Dr. *Wallis*. Yet afterwards the ſame Arithmetick was publiſh'd by Mr. *Leibnitz* in the *Acta Eruditorum*, with only changing the Name, and the Manner of Notation.

Fig. 145.

Now let a Body move in the Curve Q A O, by Means of a Centripetal Force tending to S; and let the Velocity of the Body in A be called C. Now the Velocity with which a Body at the ſame Diſtance, and with the ſame Centripetal Force would deſcribe a Circle, may be call'd *c*. It is plain from the firſt Theorem, that if S A repreſents the Centripetal Force tending to S, the Centripetal Force tending to R, by Means of which the Body with the Velocity C will deſcribe a Circle whoſe Radius is A R, will be repreſented by S P. But the Centripetal Forces of Bodies deſcribing Circles, are as the Squares of the Velocities apply'd to the Radii of the Circles. Therefore it will be $\mathrm{SP} . \mathrm{SA} :: \frac{\mathrm{C}^2}{\mathrm{AR}} . \frac{c^2}{\mathrm{SA}}$; whence $\mathrm{SP} \times \mathrm{AR} . \mathrm{SA}q :: \mathrm{C}^2 . c^2$, and therefore $\mathrm{C} . c :: \sqrt{\mathrm{SP} \times \mathrm{AR}} . \mathrm{SA}$.

If S P coincides with S A, as it is in the Vertices of the Figures, it will be $\mathrm{C} . c :: \sqrt{\mathrm{AR}} . \sqrt{\mathrm{SA}}$. Now if the Curve be a Conic Section, A R the Radius of Curvature at its Vertex will be equal to half the Latus rectum, or $\frac{1}{2}$ L, and therefore the Velocity of the Body in the Vertex of the Section will be to the Velocity of the Body deſcribing a Circle at the ſame Diſtance, in a ſubduplicate Ratio of the Latus rectum to the double Diſtance.

Becauſe it is $AR = \frac{SA \times S\dot{A}}{S\dot{P}}$, it will be $C^2 . c^2 :: \frac{SP \times SA \times S\dot{A}}{S\dot{P}} . SAq :: \frac{SP \times S\dot{A}}{S\dot{P}} . SA :: SP \times S\dot{A} . SA \times S\dot{P}$; and therefore from the given Relation of SP to SA, the Ratio of C to c will be given. For Example, if the Centripetal Force be reciprocally as the Dignity m of the Diſtance, that is, if it be $\frac{S\dot{P}}{SPc \times S\dot{A}} = \frac{b}{a^2 SA^m}$; it will be $S\dot{P} = \frac{bSPc \times S\dot{A}}{a^2 SA^m}$, and therefore it will be $C^2 . c^2 :: SP \times S\dot{A} . \frac{bSPc \times SA \times S\dot{A}}{a^2 SA^m} :: a^2 SA^{m-1} . bSPc$. Whencc if we put $SPq = \frac{d^2 SA^{m-1}}{b} = \frac{\frac{m-1}{2} a^2 SA^{m-1}}{b}$, it will be $C^2 . c^2 :: a^2 S.A^{m-1} . \frac{m-1}{2} a^2 SA^{m-1} :: m-1 . 2$; and therefore $C . c :: \surd 2 . \surd\overline{m-1}$.

Now if it be put $SPq = \frac{d^2 SA^{m-1}}{b - eSA^{m-1}} = \frac{\frac{m-1}{2} a^2 SA^{m-1}}{b - eSA^{m-1}}$, it will be $C^2 . c^2 :: a^2 SA^{m-1} . \frac{\frac{m-1}{2} a^2 b SA^{m-1}}{b - eSA^{m-1}}$, that is, as $b - eSA^{m-1}$ to $\frac{m-1}{2} b$; but the Ratio of $b - eSA^{m-1}$ to $\frac{m-1}{2} b$ is leſs than the Ratio of b to $\frac{m-1}{2} b$, or than the Ratio of 2 to $m-1$; whence C will be to c in a leſs Ratio than that of $\surd 2$ to $\surd\overline{m-1}$.

In like Manner if there be taken $SP = \frac{d^2 SA^{m-1}}{b + eSA^{m\;1}}$ it will be found that C will be to c in a greater Rttio than that of $\surd 2$ to $\surd\overline{m-1}$.

Cor. If a Body move in a Parabola, and the Centripetal Force tends to the Center S; the Velocity of the Body will be to the Velocity of the Body deſcribing a Circle at the ſame Diſtance, every where as the $\surd 2$ to 1. For in that Caſe it is $m = 2$, and $m - 1 = 1$. The Velocity of the Body in an Ellipſis is to the Velocity of the Body moving in a Circle at the ſame Diſtance, in a leſs Ratio than that of $\surd 2$ to 1. And the Velocity in an Hyperbola is to the Velocity in the Circle, in a greater Ratio than that of $\surd 2$ to 1.

If a Body moves in the Nautical Spiral, its Velocity is every where equal to the Velocity of a Body deſcribing a Circle at the ſame Diſtance; for in this Caſe 'tis $m = 3$, and $m - 1 = 2$.

Problem. Suppoſing that the Centripetal Force, (whoſe abſolute Quantity is known,) be reciprocally as the Square of the Diſtance, and a Body be projected according to a given right Line with a given Velocity; to find the Curve in which the Body will move. Fig. 153.

Let a Body be projected according to a given right Line A B, with a given Velocity C. Now becauſe the abſolute Quantity of the centripetal Force is known, the Velocity will thence be given, with which a Body can deſcribe a Circle at the Diſtance S A, by the ſame Centripetal Force. For it is equal to that which is acquired while the Body falls through $\frac{1}{2}$ S A, if urged by the ſame Force. Let that Velocity be *c*. From A upon A B let the Perpendicular A K be erected, and in that take A R, a fourth Proportional to c^2, C^2, and $\frac{SA^q}{SP}$; and A R will be the Radius of Curvature in A. From R upon A S let fall the Perpendicular R H, and from H upon A R the Perpendicular H K, and drawing the right Line S K, it will give the Poſition of the Axis. Make the Angle F A K equal to the Angle S A K; and if F A is parallel to S K, the Figure in which the Body moves will be a Parabola. But if S K meets the Axis in F, and the Points S and F fall on the ſame Side of the Point *K*, the Figure will be an Hyperbola. If the Points S and F fall on the contrary Sides, the Figure will be be an Ellipſis. Then with the Foci S and F, and with the Axis $=$ S A $\pm$ F A, the Section in which the Body will move may be deſcribed.

The Inverſe Problem *of Centripetal Forces; with Remarks on* Bernoulli; *by Dr.* John Keil, n. 340. p. 91. *Nov.* 24. 1713.

VI. To find the Curve deſcribed by a Body, which is urged by a given Law of Centripetal Force, when projected with a given Velocity from a given Place, according to a given right Line; is a Problem of the greateſt Dignity. *Newton*, in his *Mathematical Principles of Natural Philoſophy*, gave us long ſince a compleat Solution of it, granting the Quadratures of Curvilinear Figures. Since which the celebrated Mr. *John Bernoulli* has again undertaken the ſame Problem, in the *Memoirs of the Academy of* Paris *for Ann.* 1710. I have compared his Solution with that of *Newton*, and made the following Remarks upon them.

Mr. *Bernoulli* premiſes the ſame Propoſition which *Newton* makes uſe of, for demonſtrating his Problem; which is the XLth in his *Principia*, and is no leſs elegant than eaſy to be demonſtrated. It is as follows.

If a Body moves any how by Means of a Centripetal Force, and another Body aſcends or deſcends directly, and their Velocities are equal in any Caſe of equal Altitudes; their Velocities will be equal in all equal Altitudes.

Bernoulli ſays the Demonſtration of this Propoſition is deliver'd by *Newton* in too perplex a Manner; and therefore he ſubſtitutes his own in its Room, which he calls a more ſimple one. But give me Leave to ſay, without offending ſo great a Man, that if there be any Difference between the Demonſtrations of *Newton* and *Bernoulli*, it is this, that *Newton's* Fig. 154.

ton's ſeems to be much the eaſier, and leſs perplex than the other. For if with Center C the two Circles DI, EK, are deſcribed, the Diſtance of which DE is as ſmall as may be, and the Velocities of the Bodies in D and I are equal, and if from N to IK the Perpendicular NT is let fall; *Newton* fully ſhews, that the accelerating Force according to DE is to the accelerating Force according to IK, as IN to IT. For if the Force according to DE or IN be repreſented by the right Lines DE or IN, that Force, according to IN, may be reſolved into two, TI, TN, of which that only which is as TI accelerates the Motion according to the Direction IK. But the Accelerations or Increments of the Velocities are as the Forces and the Times in which they are generated conjunctly. But becauſe of the equal Velocities in D and I, the Times are as the Ways deſcribed DE, IK. Wherefore the Accelerations in the Motion of the Bodies along the Lines DE and IK, are as DE and IT, and DE and IK conjunctly; that is, as DEq or INq to the Rectangle $IT \times IK$, and therefore, becauſe of $INq = IT \times IK$, the Increments of the Velocities are equal. Therefore the Velocities in E and K are equal, and by the ſame Way of arguing they will always be found equal at equal Diſtances. This is the Sum of *Newton*'s Demonſtration, which is explain'd ſo clearly by him, that we ſhall find but few eaſier even among the Elementary Propoſitions. But *Bernoulli* does not proceed thus. He is contented to ſay, that Mechanicks ſhew the Force according to DE is to the Force according to IK, as IK to DE. Alſo that Mechanicks ſhew the Increments of the Velocities to be in the Ratio of the Forces and Times conjunctly. And that at the Beginning of the Motion ſuppoſing the Velocities to be equal, the Times are as the Ways deſcribed DE, IK. And hence he concludes, by an Argumentation altogether like that of *Newton*, that the Increment of the Velocity acquired by the Body whilſt it deſcribes IK, is to the Increment of Velocity while DE is deſcribed, as $DE \times IK$ to $IK \times DE$, and therefore that the Increments of the Velocities will always be equal in equal Diſtances.

But if he had had a Mind to give an eaſy Demonſtration for the Sake of Novices, he ought to have cited the Mechanical Propoſition, and have accommodated it to the preſent Caſe. And indeed there was Occaſion for many Words, that this may become the Theorem which he ſeems to hint at, in which is treated of the Deſcent of heavy Bodies along inclined Plains. For here no Plain is given, which may hinder the direct Deſcent of Bodies. Nay, the Body is ſo far from being hinder'd by a Plain, that on the contrary it is continually attracted by a certain Force from the Plain or Tangent. Therefore without Doubt the Force of his Reaſoning would have been more manifeſt, if forbearing to introduce his Propoſitions of Mechanicks, he had demonſtrated the whole Matter from its own genuine Principles, as *Newton* has done. For by reſolving the right-angled Triangle KNI into two ſimilar Triangles, it is KI to IN as IN to IT, and therefore inſtead of the Ratio IN to IT, he might have put the Ratio of KI to IN or DE.

Plate IX. Vol. IV. Par

Page 368

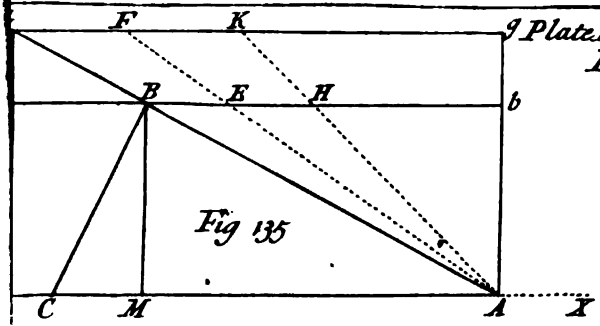


Fig 135

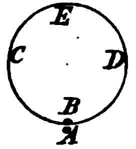
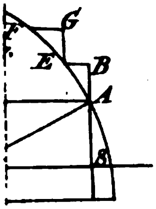


Fig 142



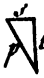


Fig. 138

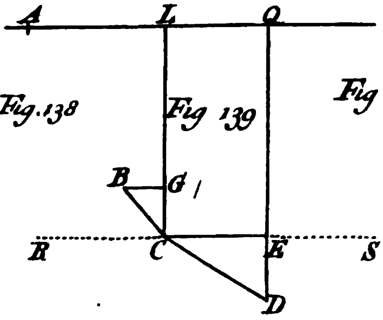


Fig 139

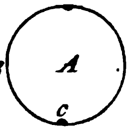


Fig 143

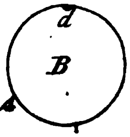
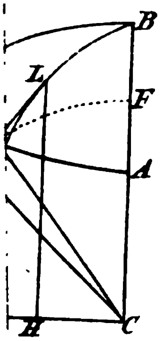


Fig. 144



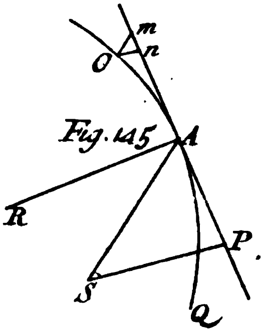


Fig. 145

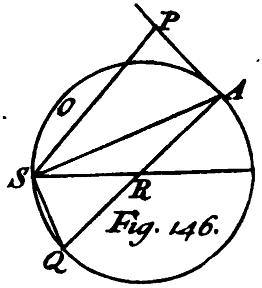
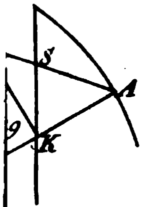


Fig. 146.



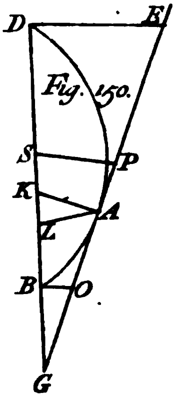


Fig. 150.

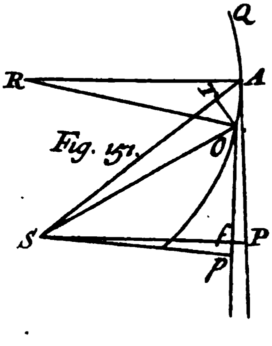


Fig. 151.

If the Body falls from any Place A in the right Line AC, and from its Place E a Perpendicular EG be always raiſed, which may be proportional to the Centripetal Force; and if BFG be the Curve Line which the Point G always touches; *Newton* demonſtrates (*Prop.* 39. and 40. of his *Principia*,) that the Velocity of the Body in any Place E is as the Square-root of the Curvilinear Area $ABGE$. Therefore if the Velocity be called v, then v^2 will be as the Area $ABGE$. And if P be the greateſt Altitude to which the Body revolving in the Trajectory can aſcend, when projected upwards from any Point of it with the Velocity which it has there; and if A be the Diſtance of the Body from the Center in any other Point of its Orbit; and if the Centripetal Force be always as any Dignity of A, ſuppoſe as A^{n-1}; the Velocity of the Body in every Altitude A will be as $\sqrt{n\,\text{[illegible]} - n A^n}$.

In like Manner Mr. *Bernoulli* ſhews, that if the Diſtance from the Center be called x, the Velocity v, and the Centripetal Force φ, it will be $v = \sqrt{ab - Flu\colon \varphi\dot{x}}$; where it is plain from Quadratures, that the Area $ABGE = ab - Flu\colon \varphi\dot{x}$. Therefore it is all one, whether the Square of the Velocity is expreſs'd by the Area $ABGE$, or by the Quantity $ab - Flu\colon \varphi\dot{x}$ which is equal to it. And if the Centripetal Force φ be as nA^{n-1} or nx^{n-1}, it will be $ab = P^n$, and $Flu\colon \varphi\dot{x} = A^n$; ſo that $ab - Flu\colon \varphi\dot{x}$ is as the Quantity $P^n - A^n$.

Let the Body deſcribe the Curve VK with a Centripetal Force tending to C, and let the Circle VXY be given, deſcribed with Center C and any Radius CV. Let Q be a conſtant Quantity, and make $\frac{Q}{A} = z$. And let KI be an Element of the Curve, IN or DE an Element of the Altitude, XY an Element of the Arch. *Newton* demonſtrates, that the Element of the Arch or XY may be expreſs'd by this Formula $\frac{Q \times IN \times CX}{AA\sqrt{ABGE - zz}}$. Likewiſe from the Premiſes Mr. *Bernoulli* making the Arch $VX = z$, and the Altitude or Diſtance $= x$, reduces the Element of the Arch to this Form $\dot{z} =$

$$\frac{a^2 c\dot{x}}{\sqrt{abx^4 - x^4 \times Flu\colon \varphi\dot{x} - a^2c^2x^2}}.$$

Now even at firſt View the Formula of *Newton* ſhould ſeem ſomething more ſimple than that of *Bernoulli*, as conſiſting of fewer Terms. But when I had examin'd the Matter carefully, I ſaw that *Bernoulli*'s Formula exactly coincided with that of *Newton*, and differ'd from it only in the Manner of denoting the Quantities. For if for $ab - Flu\colon \varphi\dot{x}$ we put $ABGE$, and for ac

we put $\mathcal{Q}$, and for x we put A, and for a we put CX, and for $\dot{x}$ we put IN; then $\frac{a^2 c \dot{x}}{\sqrt{abx^4 - x^4 \times Flu{:}\ \varphi x - a^2 c^2 x^2}} = \frac{\mathcal{Q} \times CX \times IN}{\sqrt{A^4 \times ABGE - \frac{\mathcal{Q}^2 Aqq}{Aq}}}$ $= \frac{\mathcal{Q} \times CX \times IN}{A^2 \sqrt{ABGE - \mathcal{Q}^2}}$; or putting zz inſtead of $\frac{\mathcal{Q}^2}{A^2}$, (which *Newton* does for the Sake of a more commodious Notation) *Bernoulli*'s Form becomes $\frac{\mathcal{Q} \times CX \times IN}{A^2 \sqrt{ABGE - zz}}$. Whence it appears, that his Formula does not differ from that of *Newton*, any otherwiſe than as any Thing written in *Latin* Characters would differ from the ſame Thing written in *Greek* Characters.

After having deliver'd the general Formula, Mr. *Bernoulli* deſcends to a particular Caſe, in which the Centripetal Force is reciprocally as the Square of the Diſtance. And through various Reductions and troubleſome Operations, he ſhews the Conſtruction of Curves which may be deſcribed by means of that Centripetal Force, and by reducing them to Equations he proves they are Conic Sections. Then he complains, that *Newton* ſuppoſes, without any Demonſtration, that Curves deſcribed with ſuch a Force would be Conic Sections.

It is impoſſible he ſhould think, that *Newton* was not acquainted with the Demonſtration of this Matter. For he knew very well that *Newton* was the firſt and only one that had treated of this Doctrine about Centripetal Forces in a Geometrical Manner, and had brought it to ſuch Perfection. *Bernoulli* alſo knew, that beſides giving the general Solution of the Inverſe Problem, *Newton* had ſhew'd how Curves might be conſtructed, which are deſcribed by a Centripetal Force decreaſing in a triplicate Ratio of the Diſtance, and therefore he could not be ignorant of that other Caſe. Nor indeed can I underſtand for what Reaſon *Bernoulli* objects to *Newton*, that he had omitted the Demonſtration of this Caſe; ſince he himſelf has often propoſed Theorems, whoſe Demonſtrations he has no where given. And why may not *Newton* do the ſame, when in Haſte to proceed to other Matters? But now in the new Edition of the *Principia*, he has a Demonſtration of this very Thing, which, though very ſhort, is yet much eaſier and clearer than that of *Bernoulli*.

Laſtly, that *Bernoulli* might ſhew the Neceſſity of his Demonſtration of the Inverſe Problem in this particular Caſe, he thus adds. It muſt be conſider'd, ſays he, that the Force which cauſes a Body to move in the Logarithmic Spiral muſt be reciprocally as the Cube of the Diſtance from the Center. But it does not follow from thence, that ſuch Curves muſt always be deſcribed with ſuch Forces, ſince the like Forces may alſo be the Cauſe, that the Body may move in the Hyperbolical Spiral.

I wonder truly how this great Man could imagine, that *Newton* ever drew ſuch a Conſequence. For beſides the Logarithmic Spiral *Newton* ſhews, how other Curves, infinite and different in Number, may be form'd, all which may be deſcribed with the ſame Centripetal Force as the Logarithmic Spiral. And among theſe this very Hyperbolical Spiral may be reckon'd, as we ſhall ſhew hereafter.

Now from hence *Newton* concludes, that only Conic Sections can be deſcribed by a Centripetal Force which is reciprocally proportional to the Square of the Diſtance; becauſe the Curvature of any Orbit is given, by having given the Velocity, the Centripetal Force, and the Poſition of the Tangent. But the Focus being given, the Point of Contact, and the Poſition of the Tangent, a Conic Section may always be deſcribed, which ſhall have a given Curvature. This I have ſhewn above. Therefore, by Virtue of this Force, the Body ſhall move in this Curve, and no other. Since a Body ſetting out from the ſame Place, according to the ſame Direction, with the ſame Velocity, and urged by the ſame Centripetal Force, cannot deſcribe different Courſes. Vid. Supra S. V.

In Imitation of Mr. *Bernoulli*, let me attempt to reſolve this Problem of the Inverſe Method of Centripetal Forces, but after a very different Manner; and alſo to apply it to a particular Caſe, in which the Force is reciprocally as the Cube of the Diſtance; and at the ſame Time produce a Demonſtration of *Cor.* 3. *Prop.* 41. of *Newton*'s *Principia*.

In Order to do this I muſt premiſe a few Things which I have already explain'd above. Vid. Supra S. V.

Fig. 155.

Let VIL be any Curve which a Body deſcribes by Means of a Centripetal Force tending to the Center C. Let this Curve be touch'd by the right Lines IP, Kp, in two Points I and K which are infinitely near; to which from the Center let fall the Perpendiculars CP, CF, and with Center C let the Circles KE and ID be deſcribed, and draw CI.

The Centripetal Force will be as the Quantity $\frac{Pp}{PCc \times IN}$; which Theorem, though we have demonſtrated it before, yet here is another Demonſtration. From K draw Km parallel to CP, and Kn to CI. Then becauſe of like Triangles ICP, IKN, and nKm, alſo IKm and IpP, it will be

Ip or $IP . IK :: pP . Km$,
$PC . IP :: Km . mn$,
$IN . IK :: mn . nK$. Therefore *ex æquo*,
$PC \times IN . IKq :: pP . nK$,
Therefore $nK = \frac{pP \times IKq}{PC \times IN}$.

Now the Time in which the Arch IK is deſcribed, is as the Area or Triangle ICK, or its double $PC \times IK$; therefore if the Time be given, $PC \times IK$ will be a conſtant Quantity. But in a given Time the Centripetal Force will be as the little Line Kn, which is deſcribed by that Force;

and therefore the Centripetal Force is as that little Line Kn drawn into the conſtant Quantity $\frac{1}{PCq \times IKq}$; that is, the Centripetal Force will be as $\frac{1}{PCq \times IKq} \times \frac{Pp \times IKq}{PC \times IN}$, or as the Quantity $\frac{Pp}{PCc \times IN}$. *Q. E. D.*

The Velocity of the Body in any Place is as the Path deſcribed in any the leaſt Time directly, and as that Time inverſely; and therefore is as $IK \times \frac{1}{PC \times IK}$; that is, the Velocity will be reciprocally as the Perpendicular from the Center to the Tangent.

If the Diſtance of the Body from the Center be called x, and the Perpendicular upon the Tangent p; it will be $IN = \dot{x}$, and $Pp = \dot{p}$, and the Centripetal Force may be expounded by the Quantity $\frac{f^4 \dot{p}}{p^3 \dot{x}}$, by aſſuming any Quantity for f^4.

Therefore if with Mr. *Bernoulli* we call the Centripetal Force φ, then $\frac{f^4 \dot{p}}{p^3 \dot{x}} = \varphi$, and $\frac{f^4 \dot{p}}{p^3} = \dot{x}\varphi$; and taking the Fluents of theſe Quantities, it will be $\frac{f^4}{2p^2} = Flu\text{:}\ \dot{x}\varphi$.

Now ſince the Velocity of the Body is reciprocally as the Perpendicular p, its Square may be expounded by $\frac{f^4}{2p^2}$. If therefore the Velocity is call'd v, it will be $v^2 = \frac{f^4}{2p^2}$, which is equal to the Fluent of the Quantity $\dot{x}\varphi$. And if A be the Place from whence a Body ſhould fall, in order to acquire the Velocity v in D or I, and from the Place of the Body D the Perpendicular $DF = \varphi$ be erected, then the Rectangle $DE \times DF = \dot{x}\varphi$. Now let the Curve BFG be the Curve-line, whoſe Ordinates expound the Centripetal Forces, or the Quantities φ. The Flowing Quantity of $\dot{x}\varphi$ will be the Curvilinear Area $ABFD = v^2 = \frac{f^4}{2p^2}$, and therefore v will be as the Square-root of the Area $ABFD$. Now if the Velocity be ſuch as is acquired by falling from an infinite Diſtance, then v^2 or the Fluent of $\dot{x}\varphi$ will be equal to the Area $ODFO$ indefinitely extended.

Hence the Quantity p will always be given in finite Terms, when that Curvilinear Area can be expreſs'd in finite Terms. For Inſtance, let the Centripetal Force be reciprocally as the Dignity m of the Diſtance, that is, let $\dot{x}\varphi = \frac{g\dot{x}}{x^m}$. If the Velocity of the Body be ſuch as is acquired by falling from an infinite Diſtance, then $v^2 = \frac{g}{\overline{m-1} \times x^{m-1}} = \frac{f^4}{2p^2}$. And in all theſe Caſes the Area indefinitely extended will be a finite Quantity. But the Body may revolve in a Trajectory with a Velocity, the Square of which may be either greater or leſs than the Quantity $\frac{g}{\overline{m-1} \times x^{m-1}}$, or what is equal to it. Therefore it will be $v^2 = \frac{f^4}{2p^2}$ $= \frac{g}{\overline{m-1} \times x^{m-1}} \pm e^2$.

Hence by the Action of theſe Forces, three kinds of Curves may be deſcribed, according as e^2 is a poſitive, or negative, or no Quantity.

For Example, if the Velocity is greater than that which is acquired by falling from an infinite Diſtance, it will be $\frac{f^4}{2p^2} = \frac{g}{\overline{m-1} \times x^{m-1}} + e^2$. If the Velocity be leſs, it will be $\frac{f^4}{2p^2} = \frac{g}{\overline{m-1} \times x^{m-1}} - e^2$. If equal, it will be $\frac{f^4}{2p^2} = \frac{g}{\overline{m-1} \times x^{m-1}}$.

Make $\frac{1}{2}f^4 = a^2e^2$, and $\frac{1}{m-1}g = b^2e^2$, and if the Velocity of the Body be ſuch as is acquired by falling from an infinite Diſtance, it will be $p^2 = \frac{a^2x^{m-1}}{b^2}$, or $p = \frac{ax^{\frac{m-1}{2}}}{b}$.

But if the Velocity be either greater or leſs than this Velocity, it will be as has been ſhewn, $\frac{f^4}{2p^2} = \frac{g}{\overline{m-1} \times x^{m-1}} \pm e^2 = \frac{\frac{1}{m-1}g \pm e^2x^{m-1}}{x^{m-1}}$.

Where for $\frac{1}{2}f^4$ and $\frac{g}{m-1}$ putting their Values a^2e^2 and b^2e^2, it will be $\frac{a^2e^2}{p^2} = \frac{b^2e^2 \pm e^2x^{m-1}}{x^{m-1}}$, or $\frac{a^2}{p^2} = \frac{b^2 \pm x^{m-1}}{x^{m-1}}$, and $p^2 = \frac{a^2x^{m-1}}{b^2 \pm x^{m-1}}$.

Therefore if the Centripetal Force be reciprocally as the Cube of the

Diſtance, that is, if it be $m = 3$, and $m - 1 = 2$; then $p^2 = \frac{a^2 x^2}{b^2}$, or $p^2 = \frac{a^2 x^2}{b^2 + x^2}$, or laſtly $p^2 = \frac{a^2 x^2}{b^2 - x^2}$.

In the firſt Caſe it is plain, that the Curve will be a Logarithmic Spiral; for let $p = \frac{ax}{b}$, or $b . a :: x . p$, and therefore becauſe of the conſtant Ratio b to a, the Angle CIP will be conſtant.

Now let us ſuppoſe it is $p^2 = \frac{a^2 x^2}{b^2 + x^2}$, from which Suppoſition three different Species of Curves will ariſe, according as a is greater, or equal to, or leſs than b.

Fig. 156. And firſt, let a be greater than b. With Center C, at any given Diſtance, let the Circle HYX be deſcribed, which let the right Lines CK, CI, produced meet in Y and X. And it is $INq . KNq :: IPq . PCq$, and therefore $CIq - PGq . PCq :: x^2 - p^2 . p^2 :: x^2 - \frac{a^2 x^2}{b^2 + x^2} . \frac{a^2 x^2}{b^2 + x^2} :: 1 - \frac{a^2}{b^2 + x^2} . \frac{a^2}{b^2 + x^2} :: b^2 + x^2 - a^2 . a^2$. Therefore it will be $\sqrt{x^2 + b^2 - a^2} . a :: IN . KN :: \dot{x} . \frac{a\dot{x}}{\sqrt{x^2 + b^2 - a^2}} = KN$. And becauſe a is greater than b, the Quantity $b^2 - a^2$ will be negative. Let it be $- c^2$, whence $KN = \frac{a\dot{x}}{\sqrt{x^2 - c^2}}$. Let the Radius of the Circle YH be called b, and it is $CK . KN :: CY . YX$; that is $x . \frac{a\dot{x}}{\sqrt{x^2 - c^2}} :: b . \frac{ba\dot{x}}{x\sqrt{x^2 - c^2}} = XY = \dot{y}$, if the Arch HY be called y.

Let it be $x = \frac{c^2}{z}$, whence $\dot{x} = -\frac{c^2 \dot{z}}{z^2}$, and $\frac{\dot{x}}{x} = -\frac{\dot{z}}{z}$. Alſo it will be $x^2 - c^2 = \frac{c^4}{z^2} - c^2 = \frac{c^4 - c^2 z^2}{z^2} = \frac{c^2}{z^2} \times \overline{c^2 - z^2}$. Whence $\sqrt{x^2 - c^2} = \frac{c}{z} \times \sqrt{c^2 - z^2}$. Which Values being ſubſtituted, it will be $\frac{ba\dot{x}}{x\sqrt{x^2-c^2}} = \frac{-ba\dot{z}}{c\sqrt{c^2-z^2}}$. Let it be $a . c :: n . 1$, that is, let $a = nc$, and it will be XY or $\dot{y} = -\frac{nb\dot{z}}{\sqrt{c^2-z^2}}$. But it is $\frac{nb\dot{z}}{\sqrt{c^2-z^2}} . \frac{c\dot{z}}{\sqrt{c^2-z^2}} :: nb . c$, that is, in a given Ratio. And therefore their Fluents, if they begin together, will be in the ſame Ratio. That is, it will be HY or y to the Fluent of the Quantity $\frac{c\dot{z}}{\sqrt{c^2-z^2}}$, as nb to c.

Now if Center C and Radius $CV = c$ a Circle VL be deſcribed, and if $CG = z$, and $no = \dot{z}$, then the Arch $mn = \frac{c\dot{z}}{\sqrt{c^2-z^2}}$ = Fluxion of the Arch Qm when the Fluxion is a poſitive Quantity; but when it is negative, its Fluent is the Arch Vm the Complement of the former. For an Arch and its Complement have the ſame Quantity denoting its Fluxion, but affected with contrary Signs; for when one increaſes, the other decreaſes.

Hence it is $HY . Vm :: nb . c$; but it is $CV . CH :: Ve . HY$, that is, $c . b :: Ve . \frac{b \times Ve}{c} = HY$. Therefore it will be $\frac{b \times Ve}{c} : Vm :: nb . c$. Whence $Ve . Vm :: n . 1$.

Moreover from the Nature of the Circle it will be $CG . CV :: CV . CT$, when mT touches the Circle; that is, it will be $z . c :: c . \frac{c^2}{z} = CT = x$. Hence if the Angle VCe be taken to the Angle VCm as n to 1, and Ce be produced to K, ſo that CK may be equal to the Secant CT, K will be a Point in the Curve required.

Here it may be obſerved by the Way, that if n be a Number, that is, if it be a to c, or a to $\sqrt{a^2-b^2}$ as Number to Number, the Curve VI will be an Algebraical one. For in this Caſe the Relation of mC to the Sine of the Angle VCe is defined by an Equation, and thence will be had the Relation of the Sine of the Angle VCe to CT, or CK, by ſome determinate Equation; and then at laſt an Equation will be given, which will expreſs the Relation between the Ordinate and Abſciſs, beginning from the Point C.

The Orders and Degrees of theſe Curves, in the Algebraick Scale of Equations, will be different according to the Magnitude of the Number

n. In all theſe Curves thus deſcribed, the Poſition of the Aſymptote may be thus determined. Make the Angle VCL to a right Angle as n to 1. In that Angle the Diſtance of the Body from the Center becomes infinite. Now the Square of the Perpendicular upon the Tangent PC is equal to $\frac{a^2 x^2}{b^2 + x^2}$, when x is infinite, it becomes $PCq = \frac{a^2 x^2}{x^2}$, or $PC = a$. Therefore let CR be drawn perpendicular to CL, and equal to the right Line a; and if through R be drawn RS parallel to the right Line CL, this will touch the Curve at an infinite Diſtance, or will be an Aſymptote to the Curve.

If in any of theſe Curves the Body by deſcending ſhould arrive at the loweſt Apſid; it will again aſcend from hence *in infinitum*, and will deſcribe another Curve ſimilar to the former, or rather a like Portion of the ſame Curve by its Aſcent.

Theſe Curves may wind about the Center with many Circumvolutions, before they begin to converge towards their Aſymptote, and the Angular Motion of the right Line CK will be equal to ſo many right Angles as the Number n conſiſts of Units. For Inſtance, if $n = 100$, twenty-five intire Revolutions will be compleated before the Diſtance from the Center becomes infinite.

If the Number n is increas'd, a remaining the ſame, c will be diminiſh'd. For it is $\frac{a}{n} = c$, and $\frac{a^2}{n^2} = c^2 = a^2 - b^2$; whence $\overline{n^2 - 1} \times a^2 = n^2 b^2$, and therefore $a^2 . b^2 :: n^2 . n^2 - 1$. Therefore if b^2 approaches to Equality with a^2, alſo $n^2 - 1$ will approach to a Ratio of Equality with n^2, and therefore n will be increaſed, and c will be diminiſhed in the ſame Ratio. Therefore let b^2 be ſuppoſed nearly equal to a^2, ſo that when the Difference is infinitely little, let the Number n be infinitely great, and let the Radius of the Circle c be infinitely little, or let the Circle be contracted into its Center. But although c vaniſhes thus, yet CT will not vaniſh in like Manner, if the Angle VCM be nearly a right Angle. For in every Circle, though never ſo little, the Secant of a right Angle will be an infinite Quantity. Therefore becauſe of the infinite Number n, this Curve will wind about the Center with infinite Revolutions, before it will begin to converge towards its Aſymptote.

But when c vaniſhes, it is $b = a$, and $p = \frac{ax}{\sqrt{x^2 + a^2}}$. And becauſe in every Caſe it is $\dot{y} = \frac{ba\dot{x}}{x\sqrt{x^2 + c^2}}$, when c vaniſhes it will be $\dot{y} = \frac{ba\dot{x}}{x^2}$. Whence taking the Fluents it will be $y = \frac{ba}{x}$, or $xy = ba$, which is a given Quantity.

This Curve is the Hyperbolic Spiral, which has many remarkable Properties. If any Radius CIY be drawn, meeting the Curve in I, and the Periphery of the Circle in Y, and if from C a Perpendicular CT is raiſed to CI, and IT touches the Curve in I, and meets the right Line CT in T; then CT will be a conſtant right Line, which will be equal to the Arch VE. In which Property it reſembles the Logarithmic Curve, ſince CT may be called the Subtangent of the Curve. For let the Radius of the Circle CE be b, the Arch VE be a, and let CI be called x, and VY be y. Becauſe it is $ba = xy$, it will be $\frac{ba}{x} = y$, and $\frac{ba\dot{x}}{x^2} = \dot{y}$. Alſo it is $CY \,.\, CI :: YX \,.\, NK$, that is, $b \,.\, x :: \frac{ba\dot{x}}{x^2} \,.\, NK$, which therefore is $\frac{a\dot{x}}{x}$. And becauſe it is $IN \,.\, NK :: CI \,.\, CT$, that is $\dot{x} \,.\, \frac{a\dot{x}}{x} :: x \,.\, CT = a$.

If with Center C, and any Diſtance CG, an Arch of a Circle GF is deſcribed, this Arch being intercepted between the right Line CV and the Curve, will always be equal to the conſtant right Line CT or a. For becauſe it is $VL \times CF = CV \times VE$, it will be $VL \,.\, VE :: GV \,.\, CF ::$ $VL \,.\, GF$; whence $VE = GF$. If from C be raiſed $CR = VE = FG = a$ perpendicular to CG, and through R de drawn RS parallel to GV, RS will be the Aſymptote to the Curve. For the right Line MS is equal to the Arch GF, and therefore FS, the Diſtance of the Curve from RS, is always equal to the Exceſs by which the Arch exceeds its Sine. But when the Diſtance increaſes *in infinitum*, that Exceſs will be diminiſh'd *in infinitum*, and at laſt will be leſs than any given Line, and therefore RS will be an Aſymptote to the Curve.

Now let b be greater than a; and in like Manner it will be found, as in the former Caſe, that $KN = \frac{a\dot{x}}{\sqrt{x^2 + b^2 - a^2}}$. But becauſe b exceeds a, therefore $c^2 = b^2 - a^2$ will be a poſitive Quantity, and $KN = \frac{a\dot{x}}{\sqrt{x^2 + c^2}}$. Then making the Radius of the Circle $HY = b$, we ſhall find $XY = \frac{ba\dot{x}}{x\sqrt{x^2 + c^2}}$. Make $x = \frac{c^2}{z}$, and it will be $\dot{x} = -\frac{c^2\dot{z}}{z^2}$, and $\frac{\dot{x}}{x} = -\frac{\dot{z}}{z}$. It will be alſo $x^2 = \frac{c^4}{z^2}$, and $x^2 + c^2 = \frac{c^4}{z^2} + c^2 = \frac{c^4 + c^2 z^2}{z^2} = \frac{c^2}{z^2} \times \overline{c^2 + z^2}$. Whence $\sqrt{x^2 + c^2} = \frac{c}{z} \times \sqrt{c^2 + z^2}$.

Therefore theſe Values being ſubſtituted, it will be $\frac{ba\dot{x}}{x\sqrt{x^2+c^2}} = -\frac{ba\dot{z}}{c\sqrt{c^2+z^2}} = -\dot{y}$. For the Beginning of the Arch HY may be taken ſuch, that it may increaſe and decreaſe together with the Fluent of the Quantity $\frac{-ba\dot{z}}{c\sqrt{c^2+z^2}}$. Make $nc=a$, and it will be $\frac{nb\dot{z}}{\sqrt{c^2+z^2}} = \dot{y}$, and $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{c^2+z^2}} = \frac{1}{2}b\dot{y} =$ the Sector CXY.

But it is $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{c^2+z^2}} . \frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}} :: nb^2 . c^2$; that is, in a given Ratio; and therefore the Sector CXY will be to $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$ always in a given Ratio. Therefore the Fluents of theſe Quantities will be always in the ſame Ratio, ſince they are ſuppoſed to begin together. But the Fluent of the Sector CXY is the Sector CVY; and the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$ is the Sector of the Hyperbola, which is thus ſhewn.

Fig. 158. With Center C, and half the tranſverſe Axis $CV=c$, let an equilateral Hyperbola be deſcribed, and from the two Points D and F, which are very near each other, let the Ordinates DB and EF be drawn to the Conjugate Axis; alſo draw CD and CF. Now the Increment or Fluxion of the Triangle BCD will be equal to $BE \times DB$ — Sector DCF. Whence the Sector DCF (which is the Fluxion of the Sector CVD) will be equal to $BE \times DB$ — the Increment of the Triangle BCD. And if BC be called z, becauſe of the Hyperpola it is $BDq = BCq + CVq = z^2+c^2$. Whence $BD = \sqrt{c^2+z^2}$, and $BE \times BD = \dot{z} \times \sqrt{c^2+z^2}$. But the Triangle BCD is $\frac{1}{2}z \times \sqrt{c^2+z^2}$, whoſe Fluxion is $\frac{1}{2}\dot{z} \times \sqrt{c^2+z^2} + \frac{\frac{1}{2}\dot{z}z^2}{\sqrt{c^2+z^2}}$. Let this Quantity be ſubtracted from $\dot{z}\sqrt{c^2+z^2}$, and there will remain the infinitely little Hyperbolic Sector $CDF = \frac{1}{2}\dot{z}\sqrt{c^2+z^2} - \frac{\frac{1}{2}\dot{z}z^2}{\sqrt{c^2+z^2}} = \frac{\frac{1}{2}\dot{z} \times \overline{c^2+z^2} - \frac{1}{2}\dot{z} \times z^2}{\sqrt{c^2+z^2}}$

=

$= \frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$. Therefore the Fluent of the Sector CDF is equal to the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$. Therefore the Sector CVD will be the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{c^2+z^2}}$. Moreover let the right Line DT touch the Hyperbola, and meet the Conjugate Axis in T. From the Nature of the Hyperbola it is $BC \,.\, CV :: CV \,.\, CT$, that is, $z \,.\, c :: c \,.\, \frac{cc}{z} = CT = z$. And hence ariſes this following Conſtruction.

Fig. 159. With Center C, and half the tranſverſe Axis CV, let an Equilateral Hyperbola Vm be deſcribed, and alſo a Circle Ve. Let the Circular Sector CVe be taken in Proportion to the Hyperbolic Sector CVm, as n to 1; let the right Line Tm touch the Hyperbola in m, meeting the Conjugate Axis in T, let Ce be produced to k, ſo that $Ck = CT$, and the Point k will be in the Curve required. For that Curve is ſuch, that if Ck be called x, the Perpendicular let fall from C upon the Tangent will always be equal to $\frac{ax}{\sqrt{b^2+x^2}}$. When x is infinite b^2 vaniſhes, and the Perpendicular becomes equal to a, and then CR coincides with CV. If therefore in the Conjugate Axis be taken $CR = a$, and RS be drawn parallel to CV, this will be the Aſymptote of the Curve.

If a be ſo far increaſed that the Quantity $b^2 - a^2$ may become infinitely little, then c^2 will vaniſh, and the Quantity $\frac{ba\dot{x}}{x\sqrt{x^2+c^2}}$ will be $\frac{ba\dot{x}}{x^2} = \dot{y}$. Whence if the Fluents of theſe Quantities are taken, we ſhall have $\frac{ba}{x} = y$, and $ba = xy$. That is, the Rectangle under the Circular Arch and the Diſtance of the Curve from the Center will always be a given Quantity. And upon this Account the Curve will paſs into the Hyperbolic Spiral. Therefore the Hyperbolical Spiral is a Kind of intermediate Limit between ſuch Curves as are conſtructed by Circular Sectors, and thoſe that are conſtructed by Hyperbolical Sectors. Therefore that Hyperbolical Spiral may be conceived to be formed, either by a Sector of a Circle or Ellipſis, or by a Sector of an Hyperbola, whoſe tranſverſe Axis is diminiſh'd *ad infinitum*, and the Number n is increaſed in the ſame Ratio.

Now we come to that Caſe, in which the Velocity of the Body is leſs than that which is acquired by falling from an infinite Diſtance, and wherein $p^2 = \frac{a^2x^2}{b^2 - x^2}$. And here by a like Reaſoning as in the former

Caſe we ſhall find $KN = \frac{a\dot{x}}{\sqrt{b^2 - a^2 - x^2}}$, where b^2 muſt neceſſarily be greater than a^2. Hence if $b^2 - a^2$ is called c^2, it will be $KN = \frac{a\dot{x}}{\sqrt{c^2 - x^2}}$, and therefore XY or $\dot{y} = \frac{ba\dot{x}}{x\sqrt{c^2 - x^2}}$.

Now let it be $x = \frac{c^2}{z}$, and it will be $\frac{\dot{x}}{x} = - \frac{\dot{z}}{z}$, or $\frac{ba\dot{x}}{x} = - \frac{ba\dot{z}}{z}$, and it will be $c^2 - x^2 = \frac{c^2}{z^2} \times \frac{z}{z^2 - c^2}$; which Values being ſubſtituted it will be $- \frac{ba\dot{z}}{c\sqrt{z^2 - c^2}} = \frac{ba\dot{x}}{x\sqrt{x^2 - c^2}} = - \dot{y}$. For ſuch a Beginning is to be aſſigned to the Arch VX, that it may begin together with the Fluent of the Quantity $\frac{ba\dot{z}}{c\sqrt{z^2 - c^2}}$. Whence it will be $\frac{\frac{1}{2}b^2 a\dot{z}}{c\sqrt{z^2 - c^2}} = \frac{1}{2}b\dot{y} =$ Sector $CXY = \frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{z^2 - c^2}}$, by making $nc = a$. But it is $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{z^2 - c^2}} . \frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}} :: nb^2 . c^2$, that is, in a conſtant Ratio. Wherefore the Fluents of theſe Quantities are in the ſame Ratio. That is, the Fluent of the Quantity $\frac{1}{2}b\dot{y}$ or $\frac{\frac{1}{2}nb^2\dot{z}}{\sqrt{c^2 - z^2}}$, will be to the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$, as nb^2 to c^2. But the Fluent of the Quantity $\frac{1}{2}b\dot{y}$ is the Sector CVX, and the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2 - c^2}}$ is the Sector of the Hyperbola, which is thus proved.

Fig. 160. With Center C, and tranſverſe Semiaxis $CV = c$, let an Equilateral Hyperbola be deſcribed, and from two Points B and D that are infinitely near, let the two right Lines BE and DF be drawn as Ordinates to the Axis. Alſo draw CB, CD. And the Fluxion or Increment of the Triangle $CBE =$ to the Triangle $CBD + BE \times EF$. Whence the Triangle CBD, or the leaſt Sector CBD, will be equal to the Increment of the Triangle $CBE - BE \times EF$. Let CE be called z, and it will be $BE = \sqrt{z^2 - c^2}$, and $BE \times EF = \dot{z}\sqrt{z^2 - c^2}$. Alſo the Triangle $CBE = \frac{1}{2}z\sqrt{z^2 - c^2}$, whoſe Fluxion is $\frac{1}{2}\dot{z}\sqrt{z^2 - c^2} +$

$\frac{1}{2}$

$\frac{\dot{z}\,z^2}{\sqrt{z^2-c^2}}$; from whence if the Quantity $z\sqrt{z^2-c^2}$ is ſubtracted, there will remain the leaſt Sector $CBD = \frac{\frac{1}{2}\dot{z}\,z^2}{\sqrt{z^2-c^2}} - \frac{1}{2}\dot{z}\sqrt{z^2-c^2}$ $= \frac{\frac{1}{2}\dot{z}z^2 - \frac{1}{2}\dot{z} \times z^2 - c^2}{\sqrt{z^2-c^2}} = \frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2-c^2}}$. Whence it is plain, that the Sector CBE is the Fluent of the Quantity $\frac{\frac{1}{2}c^2\dot{z}}{\sqrt{z^2-c^2}}$. Moreover if BT the Tangent of the Hyperbola meets the tranſverſe Axis in T, from the Nature of the Hyperbola it will be $CE . CV :: CV . CT$; that is, $z . c :: c . \frac{c^2}{z} = CT = x$.

Hence we deduce the following Conſtruction. With Center C, and tranſverſe Semiaxis $CV = c$, let an Equilateral Hyperbola VB be deſcribed, and a Circle CeG from the ſame Center C. To the Hyperbola draw the right Line CB, and let the Tangent of the Hyperbola BT meet the tranſverſe Axis in T. Let a Sector of the Circle CVe be taken, which may be to the Hyperbolical Sector CVB as n to 1. In Ce take $CK = CT$, and K will be a Point in the Curve required; whoſe Perpendicular let fall from the Center C to the Tangent at K, if CK be called x, will be equal to $\frac{ax}{\sqrt{b^2-x^2}}$. Fig. 161.

And a Body will move in this Curve, if acted upon by a Centripetal Force which is reciprocally as the Cube of the Diſtance, if it proceeds with a due Velocity according to the Direction of the Tangent. Now what this Velocity muſt be, which ſhall make the Body deſcribe any of theſe Curves, will be thus found.

Since the Velocity with which a Body moves in any Trajectory is reciprocally as the Quantity p, aſſuming any conſtant Quantity a, that Velocity may always be expounded by $\frac{a}{p}$. And if to the Axis CV Ordinates are drawn, which are reciprocally as the Cubes of the Diſtances from the Center, or as the Centripetal Forces, and by this Means a Curvilinear Figure is deſcribed; its Area indefinitely extended may always be expounded by $\frac{b^2}{x^2}$, as is manifeſt from the Doctrine of Quadratures. But that Area is as the Square of the Velocity which is acquired by falling from an infinite Diſtance, and therefore the Velocity acquired in this Caſe will be as $\frac{b}{x}$. Hence if this Velocity is called y, and the Velocity with which the Body moves in the Trajectory be called p; and a and b be aſſumed ſuch Quantities, that in any one Diſtance from the Center it may be $y \,.\, v :: \frac{b}{x} \,.\, \frac{a}{p}$; it will be every where and at all Diſtances $y \,.\, v :: \frac{b}{x} \,.\, \frac{a}{p} :: p \,.\, \frac{ax}{b}$. Whence if $y = v$, it will be $p = \frac{ax}{b}$, and the Curve deſcribed with this Velocity will be the nautical Spiral, or a Circle if $p = x$, and $a = b$.

If y is greater than v, then p will be greater than $\frac{ax}{b}$, and it will be equal to $\frac{ax}{\sqrt{b^2 - x^2}}$, as appears from the foregoing. Now the Curve will be conſtructed by the Hyperbolical Sector, as was ſhewn in the laſt Caſe, where the Diſtance of the Body from the Center is determined by the Concourſe of the Tangent of the Hyperbola with the tranſverſe Axis. If y be greater than v, but in ſo ſmall a Ratio that b continues greater than a; the Curve will be form'd by the ſame Hyperbolical Sector. But the Diſtance of the Body from the Center is taken from the Concourſe of the Tangent with the conjugate Axis.

If it be $y \,.\, v :: p \,.\, x$, in this Caſe it will be $a = b$, and the Curve becomes an Hyperbolical Spiral, in which it is $p = \frac{ax}{\sqrt{a^2 - x^2}}$. Hence if the Body be projected from any Place according to a given right Line, with ſuch a Velocity as may be to the Velocity acquired by falling from an infinite Diſtance, as the Diſtance of the Body from the Center to a Perpendicular let fall from the Center to the Line of Direction; that Body will move in an Hyperbolical Spiral. Laſtly, if v be ſo much greater than y, that a may alſo be greater than b, the Curve will be conſtructed by Circular Sectors. And thus from the given Velocity the Relation of the Quantities a and b may always be determin'd, and therefore the Curve will be deſcribed in which the Body will move with that Velocity. And on the contrary the Curve being given, or the Quantities a and b being given, the Velocity may be found with which that Curve will be deſcribed.

The Areas of all theſe Curves, excepting the Circle, which can be deſcribed by the Action of this Centripetal Force, are perfectly Quadrable. For firſt in the Logarithmic Spiral, becauſe it is $p = \frac{ax}{b}$, it will be $KN = \frac{a\dot{x}}{\sqrt{b^2 - a^2}} = \frac{a\dot{x}}{c}$, ſuppoſing $b^2 - a^2 = c^2$. Fig. 155.

and therefore the Triangle $C K \grave{I} = \frac{\frac{1}{2} a x \dot{x}}{c}$, whoſe Fluent is $\frac{a x^2}{4 c}$, which is the Area of the Curve.

If it is $p = \frac{a \dot{x}}{\sqrt{b^2 + x^2}}$, and a be greater than b, it has been ſhew'd that $KN = \frac{a \dot{x}}{\sqrt{x^2 + c^2}}$; whence $KN \times \frac{1}{2} C I = \frac{\frac{1}{2} a x \dot{x}}{\sqrt{x^2 + c^2}}$, whoſe Fluent is $\frac{1}{2} a \sqrt{x^2 - c^2}$ = Area of the Curve. But if a be leſs than b, it is $K N = \frac{a \dot{x}}{\sqrt{x^2 + c^2}}$, and $K N \times \frac{1}{2} C I = \frac{\frac{1}{2} a x \dot{x}}{\sqrt{x^2 + c^2}}$, whoſe Fluent is $\frac{1}{2} a \sqrt{x^2 + c^2} - Q$ = Area of the Curve. Suppoſe $x = 0$, and it will be $\frac{1}{2} a c - Q = 0$, whence $Q = \frac{1}{2} a c$, and the Area is $\frac{1}{2} a \sqrt{x^2 + c^2} - \frac{1}{2} a c$.

In the Hyperbolical Spiral the Quantity c vaniſhes, and the Area of the Curve becomes $\frac{1}{2} a x$.

If $p = \frac{a \dot{x}}{\sqrt{b^2 - x^2}}$, it has been ſhewn that $K N = \frac{a \dot{x}}{\sqrt{c^2 - x^2}}$; whence $\frac{1}{2} C I \times N K = \frac{\frac{1}{2} a x \dot{x}}{\sqrt{c^2 - x^2}}$, whoſe Fluent is $Q - \frac{1}{2} a \sqrt{c^2 - x^2}$ = Area. Make $x = 0$, and it will be $Q - \frac{1}{2} a c = 0$, or $Q = \frac{1}{2} a c$. Whence the Area will always be $\frac{1}{2} a c - \frac{1}{2} a \sqrt{c^2 - x^2}$. Make $c^2 - x^2 = 0$, or $x = c$, and the Area of the Curve will be $\frac{1}{2} a c$. Whence if the Beginning of the Area is not taken from the Beginning of x, or where $x = 0$, but where $x = c$ is the greateſt, that is, if the Area begins from V, (*See Fig.* 160.) the Area will always be equal to $\frac{1}{2} a \sqrt{c^2 - x^2}$.

The moſt ſkilful Dr. *Halley* has obſerved what follows, concerning the Areas which are deſcribed by Bodies, by Means of a Centripetal Force which is as the Cubes of the Diſtances reciprocally. Which is, if Bodies by this Law deſcribe different Circles, or different Hyperbolical Spirals; the Areas of the Sectors, as well in Circles as in all thoſe Spirals, will always be equal when deſcribed in equal Times. For the Velocities of Bodies moving in Circles by this Law, ought to be reciprocally proportional to the Radii or Diſtances, and therefore the Arches deſcribed in the ſame Time will alſo be in the ſame reciprocal Ratio of the Radii; whence it eaſily appears, that the Sectors deſcribed in the ſame Time will be equal.

In all other Curves, ſince the Velocity is to the Velocity of a Body moving in a Circle at the ſame Diſtance, as $\frac{a}{b} \times x$ to p, (*Fig.* 156.) or as

$\frac{a}{x} \times IK$ to KN; while the Body in its Trajectory deſcribes the little Line IK, another Body moving at the ſame Diſtance will deſcribe an Arch $= \frac{b}{a} \times KN$. And the Area of the Circular Sector, and that of the Trajectory deſcribed in the ſame Time, will be $\frac{b}{a} \times KN \times \frac{1}{2} CN$, and $KN \times \frac{1}{2} CN$, which two Areas are in the given Ratio of b to a. Wherefore when it is $a = b$, as it is in the Hyperbolical Spiral, the Area ſo deſcribed will always be equal to the Area of the Circular Sector, deſcribed in an equal Time.

To find the Center of Oſcillation; by Dr. Br. Taylor, n. 337. p. 11.

VII. *A Definition.* The Center of Oſcillation is a certain Point in a pendulous Body, all the Vibrations of which are perform'd after the ſame Manner and in the ſame Time, as if that only were ſuſpended on a Thread, at the ſame Diſtance from the Point of Suſpenſion.

It is hardly plain enough of itſelf, that there is ſuch a Point in a Body, the Acceleration of which, by this Definition, ought to be the ſame in all Inclinations of the pendulous Body to the Horizon, as if it was actuated only by its own Gravity; the other Particles of the whole Body giving no Impediment to its Motion. Therefore in order to the Inveſtigation of this Center, a Propoſition or two muſt be premiſed, whence it may appear that there is ſuch a Point.

Prop. 1. *Prob.* 1. In any given Inclination of a vibrating Body to the Horizon, to find a Point the Acceleration of which ſhall be the ſame, as if it were urged only by its own Gravity.

Fig. 162.

Let ABD be a Section of the propoſed Body in a Plain perpendicular to the Horizon, in which the Center of Gravity G is moved, C being the Center of Suſpenſion. Let the Body be diſtinguiſhed into Priſmatical Elements perpendicular to the Plain A B D; and therefore always parallel to the Horizon; as will eaſily appear from the Motion of the Center of Gravity G in that Plain A B D. And becauſe of this Situation, any ſuch Element may be conſidered as a Phyſical Point p, placed in the ſame Plain A B D at the Point z. Therefore let the Body propoſed be reduced to the Phyſical Plain A B D, conſiſting of ſuch Particles p.

In this Plain that the Point O may be found, whoſe proper Acceleration is not changed by the Actions of the other Particles, we muſt give Attention to the Force of every ſingle Particle p ſituate in the Point z. For from theſe Forces being conjoin'd, ariſes the abſolute Motion of the whole Plain. By means of this is given the Motion of every Point propoſed, whence in its Turn is found that Point, the Motion of which is given.

But the Particle p will be urged by the Force of its own Gravity, which in a given little Time, if the Coheſion of the Particles were diſſolved,

ſolved, would produce a given Acceleration of Motion in the Perpendicular to the Horizon zy. Draw yx perpendicular to Cz, and the Acceleration zy will be reſolved into the Parts zx and xy. Becauſe of the Rigidity of the Body the Force zx will be taken away by the Reſiſtance of the Point C. But by the other Force xy the Space ABD is drawn round about the Point C. And drawing an Horizontal Line Cs, and a Perpendicular zs, it will be as $\frac{Cs}{Cz}$; becauſe of the given Force of Gravity, and the ſimilar Triangles xyz and sCz. Therefore the Force of the Particle p, to move the Space ABD, will be as $\frac{Cs}{Cz} \times p$.

To collect theſe Forces together, let O be an invariable Point, in a Line drawn at Pleaſure, and at a Diſtance CO, which is yet unknown. Then the Force of the Particle p to move the Point O, will be as $\frac{Cz}{CO} \times \frac{Cs}{Cz} \times p$, that is, as $\frac{Cs}{CO} \times p$. But the Acceleration which p contributes to the ſame Point O, will be as $\frac{CO}{Cz} \times \frac{Cs}{Cz}$. Therefore the Force $\frac{Cs}{CO} \times p$ being apply'd to the Acceleration $\frac{CO \times CS}{Czq}$, the Quotient will be $\frac{Czq}{COq} \times$ Particle p, which if it be ſuppoſed to move in the Point O with the ſame Acceleration $\frac{CO \times Cs}{Czq}$, would produce the ſame Motion intirely, as the Particle p produces in the ſame Point O. Thus at laſt the Problem is reduced to a well known Theorem of Motion; for the Sum of the Forces $\frac{Cs}{CO} \times p$ being apply'd to the Sum of the Particles $\frac{Czq}{COq} \times p$, the Quotient will be the abſolute Acceleration of the Point O. Then drawing the Perpendicular Oo, and ſuppoſing this Acceleration to be equal to the given Acceleration $\frac{Co}{CO}$ of the Point O, the Diſtance CO will be given. For let $\frac{Co}{CO} = d$, and by the Method of Fluxions 'tis $Cs \times p = \dot{M}$, and $Czq \times p = \dot{C}$. Then becauſe of CO being invariable, the Sum of all the Forces will be $\frac{Cs}{CO} \times p = \frac{M}{CO}$, and the Sum of all the Particles $\frac{Czq}{COq} \times p = \frac{C}{COq}$. Whence applying the

Sum of the Moments to the Sum of the Bodies, it will be $\frac{M}{C} \times CO = d$, and therefore $CO = \frac{dC}{M}$. Therefore C and M being found, CO will be given by the inverſe Method of Fluxions. Q. E. I.

Cor. From the Center of Gravity G draw G*g* perpendicular to the Horizontal Line C*o*, and let the Body itſelf A B C be called A. Then from the well known Property of the Center of Gravity, it will be $M = Cg \times A$. Whence it is $CO = \frac{dC}{Cg \times A}$.

Prop. 2. *Theor.* 1. The ſame Things being ſuppoſed, let the Point O be ſought, in the right Line C G paſſing through the Center of Gravity G; then will O be the Center of Oſcillation of the Body A.

Fig. 163. For in this Caſe it is $\frac{Co}{CO} = \frac{Cg}{CG} = d$. Whence $CO = \left(\frac{dC}{Cg \times A}\right.$, by *Cor.* of *Prop.* 1. $\left.=\right) \frac{C}{CG \times A}$. But A is given, and the Point C being given, CG and the Quantity C are given. Whence CO is given, whatever be the Inclination of the vibrating Body to the Horizon. Therefore by the Definition, and by *Prob.* 1. O is the Center of Oſcillation of the Body A. Q. E. D.

Prop. 3. *Theor.* 2. The ſame Things being ſuppoſed, let D be the Aggregate of all the $Gz^2 \times p$. Then it will be $CO = CG + \frac{D}{CG \times A}$.

Draw *z*F perpendicular to CG, and it will be $Czq = CGq + Gzq - 2\,CG \times GF$, when F falls between C and G. But when F falls in C G produced, it will be $Czq = CGq + Gzq + 2\,CG \times Gf$. Therefore C = (Aggregate of all the $Czq \times p =$) Aggregate of all the $CGq \times p + Gzq \times p - 2\,CG \times GF \times p + 2\,CG \times Gf \times p$. But Fig. 164. becauſe of G the Center of Gravity, the Aggregate of all the $2\,CG \times GF \times p$ = Aggregate of all the $2\,CG \times Gf \times p$. Wherefore it is C = the Aggregate of all the $CGq \times p + Gzq \times p = CGq \times \overline{A + D}$. But by *Theorem* 1. it is $CO = \frac{C}{CG \times A}$. Therefore $CO = CG + \frac{D}{CG \times A}$. Q. E. D.

Cor. Hence the Parallelogram CG × GO is given. For it is $GO = \frac{D}{CG \times A}$. But A and D are given. Therefore $CG \times GO = \frac{D}{A}$ is given.

Prop. 4. *Theor.* 3. The ſame Things being ſuppoſed, if in the Point O the Phyſical Particle $\frac{CG \times A}{CO}$ is conſtituted, which being actuated by its own Gravity ſhall vibrate about the Point C; the Motion of the Space A B C ſhall be juſt the ſame, as if it were agitated by the Oſcillation of the Body A.

It is evident, as well from the Nature of the Center of Gravity, as by *Prob.* 1. For $\frac{CG \times A}{CO}$ is the Aggregate of all the $\frac{Czq \times p}{COq} = \frac{C}{COq}$.

Prop. 5. *Prob.* 2. The Magnitude of any Body A, the Center of Gravity G, and the Point of Suſpenſion C being given; to find O the Center of Oſcillation of the ſame.

It is perform'd by *Theor.* 1. by finding the Quantity C; or by *Theor.* 2. by ſeeking the Quantity D.

Scholium. For performing the Calculation in a particular Caſe, the Quantity C or D is to be made choiſe of, according as the Nature of the propoſed Figure ſhall ſuggeſt. Then either of them being given, the other alſo will be given by the Equation (*Prop.* 3.) $C = CGq \times \overline{A + D}$. Whence alſo will be given the Parallelogram $CG \times GO = \frac{D}{A}$, (*Cor. Prop.* 3.) $= \frac{C}{A} - CGq$, by Help of which, from the Center of Gravity and the Point of Suſpenſion being given, the Center of Oſcillation is given by Diviſion only. Therefore in every Example it will always be moſt convenient to find this Parallelogram firſt, either by the Computation of D, or by the Quantity C, by a proper Aſſumption of the Center of Suſpenſion.

What remains is, to illuſtrate this by ſome Examples.

Ex. 1. Let the Figure propoſed be the Pyramid A D C, whoſe Baſe is the Parallelogram A D, and let the Motion of the Center of Gravity be in a Plain paſſing through the Vertex C, and the Diameter of the Baſe E F parallel to the Side A B. Fig. 165.

To perform the Calculation moſt conveniently, let the Vertex itſelf C be the Point of Suſpenſion. Then in the Manner of *Prob.* 1. let the Figure be reduced to a Phyſical Plain of the Iſoſceles Triangle C E F, in which *ef* parallel to E F repreſents a Phyſical Line compoſed of Particles *p*. Let $CH = a$, $HF = b$, and $Cb = x$. Then from the Nature of the Figure it will be $eb = \frac{bx}{a}$, and the Particle *p* placed at the Point *z* will be as *x*. Or rather, making $bz = v$, then vx will be the Baſe of the Elementary Priſm, and *p* will be as vxx. Fig. 166.

Whence it will be $\dot{C} = Czq \times \dot{v}\dot{x}x = \dot{v}\dot{x}x^3 + \dot{x}\dot{v}v^2x$. Therefore the Sum of all the $Czq + p$ in the Line bz will be $v\dot{x}x^3 + \frac{1}{3}\dot{x}xv^3$; and in the Line ef, (putting $\frac{bx}{a}$ for v) that Sum will be $\frac{6ba^2 + 2b^3}{3a^3} \times \dot{x}x^4$. Whence again taking the Fluent, and writing a for x, it will be $C = \frac{6ba^2 + 2b^3}{15} \times a^2$. But the Pyramid itſelf is $A = \frac{3baa}{3}$, and the Diſtance of the Center of Gravity G from the Vertex C is $CG = \frac{3}{4}a$. Whence $\frac{C}{A} - CGq = \frac{D}{A} = CG \times GO = \frac{3a^2 + 16b^2}{80}$.

Ex. 2. Let the Figure propoſed be an erect Cone, deſcribed by the Rotation of the Iſoſceles Triangle ECF about the Perpendicular CH.

Here again taking the Vertex C for the Center of Suſpenſion, and making $CH = a$, $HE = b$, $Cb = x$, $bz = v$, as above; it will be $p = 2\dot{x}\dot{v}\sqrt{\frac{bb}{aa}xx - vv}$; whence $\dot{C} = 2\dot{v}\dot{x} \times \overline{xx + vv} \times \sqrt{\frac{bb}{aa}xx - vv}$. Let B be the Segment of a Circle deſcribed with the Diameter ef, which adjoins to the Abſciſs $bz = v$, and to the Ordinate $\sqrt{\frac{bb}{aa}xx - vv}$. Then the Sum of all the $Czq \times p$ in the right Line $bz = 2\dot{x} \times \frac{4a^2 + b^2}{4a^2} \times x^2 B - \frac{1}{2}\dot{x}v \times \overline{\frac{b^2}{a^2}x^2 - v^2}\Big|^{\frac{3}{2}}$. And ſince $v = eb$, this Sum will be $2\dot{x} \times \frac{4a^2 + b^2}{4a^2}x^2 B$, the Double of which $\frac{4a^2 + b^2}{a^2} \times \dot{x}x^2 B$ is a Part of C in ef. But the Area B is as x^2; therefore $B = cx^2$. And that Part of C will be $\frac{4a^2 + b^2}{a^2} \times c\dot{x}x^4$. Whence taking the Fluent it will be $C = \frac{4a^2 + b^2}{5} \times ca^3$. But the Cone itſelf $A = \frac{4}{3}ca^3$, and $CG = \frac{3}{4}a$. Wherefore $\frac{C}{A} - CGq = \frac{D}{A} = \frac{3a^2 + 12b^2}{80}$.

And in the ſame Manner the Calculus proceeds in other Figures, wherein the Ratio's of Cb to be, and of bz to p, are ſtill more compounded.

Ex. 3. That the Manner of the Calculation of the Quantity D may appear, let the propoſed Figure be a Parallelepiped, whoſe Face perpendicular to the Horizon is A B D, parallel to the Plain of the Motion of the Center of Gravity. Draw the Diameters E F and H I, and let the Altitude of the Elements be p, and draw $t\,r$ parallel to *H I*. Make G F $= a$, G H $= b$, G $s = x$, and $s\,z = v$. Then it will be $\dot{D} = \dot{v}xx\dot{x} + \dot{x}vv\dot{v}$. Whence the Part of D in the right Line $t\,r$ will be $2b\dot{x}x^2 + 2b^3\dot{x}$; and again taking the Double of the Fluent, it will be $D = \frac{4ba^3 + 4b^3a}{3}$. But $A = 4ab$. Whence $\frac{D}{A} = \frac{a^2 + b^2}{3} = \frac{1}{12}$ D B q. Fig. 167.

Ex. 4. Let the laſt Example be in the Sphere, whoſe greateſt Circle is B $t\,r$, Diameter A B, and Center G. Then drawing Lines as in the Scheme, it will be $\dot{D} =$ G $s\,q \times p +$ G M $q \times p$. But the Sum of all the G $s\,q \times p$ in the right Line $t\,r$ is G $s\,q$, drawn into the Area of the Circle deſcribed with the Diameter $t\,r$. Alſo the Sum of all the G M $q \times p$ in the right Line $k\,i$ is G M q, drawn into the Area of the Circle deſcribed with the Diameter $k\,i$. whence it eaſily appears, that D is equal to four Times the Fluent of G $s\,q$ into the Area of the Circle whoſe Diameter is $t\,r$. Let therefore c be the Area of the Circle, the Square of whoſe Radius is 1, and let it be G A $= a$, and G $s = x$. Then it will be $\dot{D} = 4\dot{x}x^2 \times ca^2 - cx^2 = 4ca^2\dot{x}x^2 - 4c\dot{x}x^4$. Whence taking the Fluent, and making $x = a$, it will be $D = \frac{8}{15}ca^5$. But $A = \frac{4ca^3}{3}$. Whence $\frac{D}{A} = \frac{2}{5}aa$. Fig. 168.

Becauſe of the Affinity of Solution, I have a Mind to add here a Problem concerning the finding the Center of Percuſſion.

Prop. 6. *Prob.* 3. To find the Center of Percuſſion of any Body, having a Rotation about a given Point, which Point muſt be ſuch, that a Body ſtriking againſt it, and at the ſame Time being let looſe from the Center of Suſpenſion, ſhall incline neither this Way or that Way.

Firſt it appears, that this Point muſt be ſought for in the Plain of Motion of the Center of Gravity. For if the Body is reſolved into Priſmatic Elements perpendicular to that Plain, they will be carried by a Motion parallel to one another; whence the Moments on each Side of that Plain will be equal: Therefore by the Reſiſtance made in this Plain, no Point of the Body will be driven out of it. Therefore let that Plain be A B, to which let the Body be reduced, by a Contraction of the Priſmatic Elements into Particles p ſituated at the Points z, as in *Prob.* 1. In this Plain let C be the Center of Rotation, or at leaſt its Projection made Fig. 169.

made by a Line let fall perpendicularly upon this Plain; and let Q be the Point ſought. Through C draw $C\xi$ at Pleaſure, in which take two Points z and ξ, ſo that drawing zQ and ξQ, the Angle CzQ may be obtuſe, and the Angle $C\xi Q$ acute; and in the Points z and ξ let there be Particles p and π. Then drawing zr and $\xi\rho$ perpendicular to $C\xi$, which may be to each other as Cz to $C\xi$, by theſe will be repreſented the abſolute Velocities of the Particles p and π. But certain Parts of theſe Velocities, which are in the Directions of zQ and ξQ, are taken away by the Reſiſtance of the Point Q. Draw CD and Cd perpendicular to Qz and $Q\xi$, and becauſe of equal Angles $zCD = rzQ$, and $\xi Cd = r\xi Q$, the other Parts of the Velocities, which are in Directions perpendicular to Qz and $Q\xi$, will be as zD and ξd. So that in reſpect of the Diſtances Qz and $Q\xi$, the Forces of the Particles p and π, to move the Space AB the contrary Way, will be as $Dz \times zQ \times p$, and $d\xi \times \xi Q \times p$. Now by the Conditions of the Problem theſe Sums of contrary Forces ought to be equal.

Becauſe of the right Angles at D and d, the Points D and d are in the Circumference of a Circle deſcribed with the Diameter CQ. Let E be the Center of this Circle. Then drawing Ez and $E\xi$, meeting the Circle in F and I, f and i, it will be $Dz \times zQ = Fz \times zI = EFq - Ezq = EQq - Ezq$; and $d\xi \times \xi Q = E\xi q - EQq$. Then the Sum of all the $EQq \times p - Ezq \times p$ will be equal to the Sum of all the $E\xi q \times \pi - EQq \times \pi$. And tranſpoſing the Terms, the Sum of all the $EQq \times \overline{p + \pi}$ will be equal to the Sum of all the $Ezq \times p + E\xi q \times \pi$: That is, if p be put as well for the Particle p within the Circle, as for the Particle π without the Circle; the Sum of all the $EQq \times p$ will be equal to the Sum of all the $Ezq \times p$. Draw zs perpendicular to CQ. Then it will be $Ezq = Czq + ECq - QC \times Cs$. Now this Value of Ezq being ſubſtituted inſtead of it, and the Equation being rightly managed, you will find at laſt the Sum of all the $CQ \times Cs \times p =$ to the Sum of all the $Czq \times p$. Whence it will be $CQ = \dfrac{\text{Sum of all the } Czq \times p}{\text{Sum of all the } Cs \times p}$. But the Sum of all the $Czq \times p$ is the Quantity C itſelf in the Calculation of the Center of Oſcillation; and if the Center of Gravity be G, and Gg be drawn perpendicular to CQ, and the Body itſelf be called *A*, the Sum of all the $Cs \times p$ will be equal to $Gg \times A$. Whence it is $CQ = \dfrac{C}{Cg \times A}$. Let the Center of Oſcillation be O; then by *Theor.* 1. $CO = \dfrac{C}{CG \times A}$. Whence it is $Cg . CG :: CO . CQ$. Wherefore a Perpendicular to CO being drawn through O; it will paſs through the Point Q. *Q. E. I.*

VIII. A

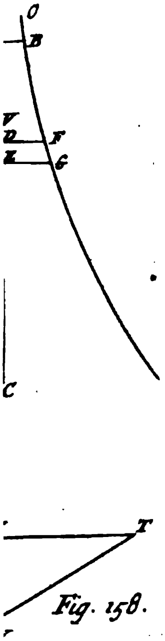
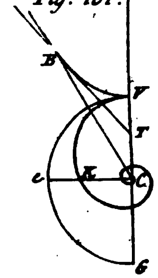


Fig. 158.

Fig. 161.



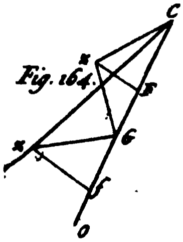


Fig. 164.

Of the Motion *of a* Stretch'd String, *by Dr.* B Taylor, n. 337. p. 26.

VIII. A *Lemma.* Let ADFB, $A\Delta\phi B$, be two Curves, the Relation of which is ſuch, that the Ordinates $C\Delta D$, $E\phi F$, being drawn, it may be $C\Delta . CD :: E\phi . EF$. Then the Ordinates being diminiſh'd *ad infinitum*, ſo that the Curves may coincide with the Axis A B; I ſay that the ultimate Ratio of the Curvature in Δ will be to the Curvature in D, as $C\Delta$ to CD.

Fig. 170.

Demonſt. Draw the Ordinate $c\,\delta\,d$ very near to CD, and at D and Δ draw the Tangents Dt and $\Delta\theta$, meeting the Ordinate cd in t and θ. Then becauſe of $c\delta . cd :: C\Delta . CD$, (by Hypotheſis) the Tangents being produced will meet one another and the Axis in the ſame Point P. Whence becauſe of ſimilar Triangles CDP and ctP, $C\Delta P$, and $c\theta P$, it will be $c\theta . ct :: C\Delta . CD :: c\delta . cd$ (by Hyp.) $:: \delta\theta . (c\theta - c\delta) . dt (ct - cd.)$ But the Curvatures in Δ and D are as the Angles of Contact $\theta\Delta\delta$ and tDd; and becauſe $\delta\Delta$ and dD coinciding with cC, thoſe Angles are as their Subtenſes $\delta\theta$, dt; that is, by the Proportion above, as $C\Delta$, CD. Therefore, &c. *Q. E. D.*

Fig. 171.

Lem. 2. In ſome Inſtant of its Vibration, let a String ſtretch'd between the Points A and B put on the Form of any Curve $Ap\pi B$, I ſay that the Increment of the Velocity of any Point P, or the Acceleration ariſing from the Force of the Tenſion of the String, is as the Curvature of the String in the ſame Point.

Demonſt. Conceive the String to conſiſt of equal rigid Particles, which are infinitely little, as pP, $P\pi$, &c. and at the Point P erect a Perpendicular PR, equal to the Radius of Curvature in P, which let the Tangents pt, πt, meet in t, the Parallels to them πs, ps, in s, the Chord $p\pi$ in c. Then by the Principles of Mechanicks, the abſolute Force by which the two Particles pP and $P\pi$ are urged towards R, will be to the Force of the Tenſion of the String, as st to tp; and half this Force, by which one Particle pP is urged, will be to the Tenſion of the String, as ct to tp, that is, (becauſe of ſimilar Triangles ctp, tpR) as tp or Pp to Rt or PR. Wherefore, becauſe of the Force of Tenſion being given, the abſolute accelerating Force will be as $\frac{Pp}{PR}$. But the Acceleration generated is in a compound Ratio of the Ratios of the abſolute Force directly, and of the Matter to be moved inverſely, and the Matter to be moved is the Particle itſelf Pp. Wherefore the Acceleration is as $\frac{1}{PR}$, that is, as the Curvature in P. For the Curvature is reciprocally as the Radius of Curvature in that Point. *Q. E. D.*

Prob. 1. To determine the Motion of a ſtretch'd String.

In this and the following Problems I ſuppoſe the String to move from the Axis of Motion through an indefinitely little Space; that the Increment of Tenſion from the Increaſe of the Length, alſo the Obliquity of the Radii of Curvature, may ſafely be neglected.

Fig. 172.

Therefore let the String be ſtretch'd between the Points A and B, and with a Bow let the Point z be drawn to the Diſtance Cz from the

Axis A B. Then taking away the Bow, becauſe of the Flexure in the Point C alone, that will firſt begin to move, (by *Lem.* 2.) But no ſooner will the String be bent in the neareſt Points φ and *d*, but theſe Points alſo will begin to move; and then E and *e*, and ſo on. Alſo becauſe of the great Flexure in C, that Point will firſt move very ſwiftly, and thence the Curvature being increaſed in the next Points, D, E, *&c.* they will immediately be accelerated more ſwiftly; and at the ſame Time the Curvature in C being diminiſh'd; that Point in its Turn will be accelerated more ſlowly. And in general, thoſe Points which are ſlower than they ſhould be, being accelerated more, and the quicker leſs, it will be brought about at laſt, that the Forces being duly attemper'd one with another, all the Motions will conſpire together, and all the Points will at the ſame Time approach to the Axis, going and returning alternately *ad infinitum.*

Now that this may be done, the String muſt always put on the Form of the Curve A C D E B, the Curvature of which in any Point E is as the Diſtance of the ſame E η from the Axis; the Velocities of the Points C, D, E, *&c.* being alſo in the Ratio of the Diſtances from the Axis C *z*, D θ, E η, *&c.* For in this Caſe the Spaces C κ, D δ, E ε, *&c.* deſcribed in the ſame infinitely little Time, will be as the Velocities, that is, as the Spaces deſcribed D *z*, D ϑ, *&c.* Wherefore the remaining Spaces κ *z*, δ ϑ, ε η, *&c.* will be to each other in the ſame Ratio. Alſo by *Lemma* 2. the Accelerations will be to one another in the ſame Ratio. By which Means the Ratio of the Velocities always continuing the ſame with the Ratio of the Spaces to be deſcribed, all the Points will arrive at the Axis at the ſame Time, and always depart from it at the ſame Time. And therefore the Curve A C D E B will be rightly determined. *Q. E. D.*

Moreover the two Curves A C D E B and A κ δ ε B being compared together, by *Lemma* 1. the Curvatures in D and δ will be as the Diſtances from the Axis D ϑ and δ ϑ; and therefore by *Lemma* 2. the Acceleration of any given Point in the String will be as its Diſtance from the Axis. Whence, (by *Sect.* 10. *Prop.* 51. of *Newton*'s *Principia*,) all the Vibrations both great and ſmall will be perform'd in the ſame periodical Time, and the Motion of any Point will be ſimilar to the Oſcillation of a Body vibrating in Cycloid. *Q. E. I.*

Cor. Curvatures are reciprocally as the Radii of Circles of the ſame Degree of Curvature. Therefore let *a* be a given Line, and the Radius of Curvature in E will be equal to $\frac{aa}{E\eta}$.

Prob. 2. The Length and Weight of a String being given, together with the Weight that ſtretches the String, to find the Time of a ſingle Vibration.

Fig. 173. Let the String be ſtretch'd between the Points A and B by the Force of the Weight P, and let the Weight of the String itſelf be *N*, and its Length L. Alſo let the String be put in the Poſition A F *p* C B, and at the middle Point C let C S a Perpendicular be raiſed, equal to the Radius of the Curvature in C, and meeting the Axis A B in D; and taking a Point *p* near to C, draw the Perpendicular *p c* and the Tangent *p t*.

Therefore it appears, as in *Lemma* 2. that the abſolute Force by which the Particle p C is accelerated, is to the Force of the Weight P, as $c\,t$ to $p\,t$, that is, as p C to C S. But the Weight P is to the Weight of the Particle p C, in a Ratio compounded of the Ratio's of P to N; and of N to the Weight of the Particle p C, or of L to p C; that is, as P × L to N × p C. Therefore compounding theſe Ratio's, the accelerating Force is to the Force of Gravity, as P × L to N × C S. Let therefore a *Pendulum* be conſtructed, whoſe Length is C D; then by *Sect.* X. *Prop.* 52. of *Newton*'s *Principia*, the periodical Time of the String will be to the periodical Time of that *Pendulum*, as $\sqrt{N \times CS}$ to $\sqrt{P \times L}$. But by the ſame Propoſition, the Force of Gravity being given, the Longitudes of the *Pendula* are in a duplicate Ratio of the periodical Times. Whence $\frac{N \times CS \times CD}{P \times L}$, or writing $\frac{aa}{CD}$ for CS, by *Cor. Prob.* 1. $\frac{N \times aa}{P \times L}$ will be the Length of a *Pendulum*, the Vibrations of which are iſochronous to the Vibrations of the String.

To find the Line a, let the Abſciſs of the Curve be A E $= z$, and the Ordinate E F $= x$, and the Curve itſelf A F $= v$, and C D $= b$. Then by *Cor. Prob.* 1. the Radius of Curvature in F will be $\frac{aa}{x}$. But $\dot{v}$ being given, the Radius of Curvature is $\frac{\dot{v}\,\dot{x}}{\ddot{z}}$. Whence $\frac{aa}{x} = \frac{\dot{v}\,\dot{x}}{\ddot{z}}$, and therefore $aa\ddot{z} = \dot{v}\,x\,\dot{x}$, and taking the Fluents $aa\dot{z} = \frac{\dot{v}\,x^2}{2} - \frac{\dot{v}\,b^2}{2} + \dot{v}\,a^2$. Here the given Quantity $-\frac{\dot{v}\,b^2}{2} + \dot{v}\,a^2$ is added, that it may be $\dot{z} = \dot{v}$ in the middle Point C. And hence the Calculus being compleated, it will be $\dot{z} = \frac{a^2\dot{x} - \frac{1}{2}b^2\dot{x} + \frac{1}{2}x^2\dot{x}}{\sqrt{a^2b^2 - a^2x^2 - \frac{1}{4}x^4 - \frac{1}{4}b^4 + \frac{1}{2}b^2x^2}}$. Now let b and x vaniſh in reſpect of a, that the Curve may coincide with the Axis, and it will be $\dot{z} = \frac{a\dot{x}}{\sqrt{bb - xx}}$. Now with Center C, and Radius D C $= b$, a Quadrant of a Circle D P E being deſcribed, and making C Q $= x$, and erecting the Perpendicular Q P; then the Arch D P being $= y$, it will be $\dot{y} = \frac{b\dot{x}}{\sqrt{bb - xx}} = \frac{b}{a}\dot{z}$. Fig. 174.

Whence $y = \frac{b}{a}z$, and $z = \frac{a}{b}y$. And making $x = b =$ C D, in which Caſe it is alſo $y =$ Quadrantal Arch D P E, and $z = \mathrm{AD} = \frac{1}{2}\mathrm{L}$; it will be $\frac{1}{2}\mathrm{L} = a \times \frac{\mathrm{DE}}{\mathrm{CD}}$, and $a = \mathrm{L} \times \frac{\mathrm{CD}}{2\,\mathrm{DE}}$. Let it be therefore C D. 2 D E :: Diameter of a Circle. Circumference :: $d . c$; and it will be $aa = \mathrm{LL} \times \frac{dd}{cc}$. Therefore this Value being ſubſtituted for aa; $\frac{\mathrm{N}}{\mathrm{P}} \times \mathrm{L} \times \frac{dd}{cc}$ will be the Length of a *Pendulum* which will be iſochronous to the String. Therefore let D be the Length whoſe periodical Time is 1, and $\frac{d}{c}\sqrt{\frac{\mathrm{N}}{\mathrm{P}} \times \frac{\mathrm{L}}{\mathrm{D}}}$ will be the periodical Time of the String. *Q. E. I.* For the Periodical Times of *Pendulums* are as the Square-roots of their Lengths.

Cor. 1. The Number of Vibrations of the String in the Time of one Vibration of the *Pendulum* D, is $\frac{c}{d}\sqrt{\frac{\mathrm{P}}{\mathrm{N}} \times \frac{\mathrm{D}}{\mathrm{L}}}$.

Cor. 2. Becauſe $\frac{d}{c} \times \sqrt{\frac{1}{\mathrm{D}}}$ is given, the periodical Time of the String is as $\sqrt{\frac{\mathrm{N}}{\mathrm{P}} \times \mathrm{L}}$. And the Weight P being given, the Time is as $\sqrt{\mathrm{N} \times \mathrm{L}}$. And the Strings being made of the ſame Thread, in which Caſe 'tis N as L, the Time will be as L.

The Invention *of making* Clocks *to keep* Time *with the* Sun's apparent Motion, *aſſerted by Mr.* J. Williamſon, n. 363. p. 1080.

IX. In a *French* Book lately publiſhed, the Author ſpeaks of making Clocks to agree with the Sun's apparent Motion; and ſuppoſed that it was a Thing never thought of by any before himſelf: I ſhall therefore give this ſhort Account of what I have performed in that Matter myſelf.

And in the firſt Place I muſt take Notice of the Copy of a Letter in this Book, wrote by one *P. Kreſa* a *Jeſuit*, to one Mr. *Williamſon*, Clockmaker to his *Imperial* Majeſty, of a Clock found in the late King *Charles* the *Second* of *Spain*'s Cabinet, about the Year 1699 or 1700. which ſheweth both equal and apparent Time according to the Tables of the Equation; and which went 400 Days without winding up. This I am well ſatisfied is a Clock of my own making; for about ſix Years before that Time, I made one for Mr. *Daniel Quare*, which agrees with the Deſcription he gives of it, and went 400 Days as he ſaith. This Clock Mr. *Daniel Quare* ſold, ſoon after it was made, to go to the ſaid King *Charles* the *Second* of *Spain*: And it was made ſo, that if the *Pendulum* was adjuſted to the Sun's mean Motion, the Hands would ſhow equal Time on two fixed Circles, on one the Hour, and on the other the Minute. But there were other two moveable Circles of the ſame kind, that moved forwards and backwards, as the Time of the Year required; on which the ſame Hands ſhew apparent Time likewiſe, according to the Equation Tables. This Method the Author owns he knew of, and applied the ſame Motion to Pocket Watches 12 or 14 Years ago, which I confeſs I never did; being well ſatisfied that Watches with Springs and Balances are very unfit to ſhew the minute Difference, as it increaſeth and decreaſeth, between equal and apparent Time.

Soon after this Clock was ſent to *Spain*, I made others for Mr. *Quare*, which ſhewed apparent Time by lengthening and ſhortening the *Pendulum*, in lifting it up and letting it down again, by a Rowler ſomewhat in the Form of an *Ellipſis*, through a Slit in a Piece of Braſs, which the Spring at the Top of the *Pendulum* went through. By this Means every Vibration of the *Pendulum*, would agree to a ſecond of Time of the Sun's apparent Motion; that Rowler, which lifted up the *Pendulum*, and let it down again, being continually moving about all the Year; ſo that it may ſeem very ſtrange, that this Author never heard of it ſo many Years after they were made: For one of thoſe, and not the firſt, made with the riſing and ſetting of the Sun, Mr. *Quare* ſold to the late King *William*, and it was ſet up at *Hampton-Court*, where it hath been ever ſince. This Contrivance of lengthening and ſhortening the *Pendulum*, I thought of ſeveral Years before I made any of them. Since then I have made others for Mr. *Quare* likewiſe, which ſhewed the Difference between equal and apparent Time according to the Equation Tables, by a Hand moving both Ways from the Top of a Circle; on one Side ſhewing how much a Clock, keeping equal Time, ought to be faſter than the Sun; on the other Side how much ſlower.

But theſe Clocks that I then made to agree with the Sun's apparent Time, were done according to the Equation Tables, which I found not to agree very exactly with the Sun's apparent Motion: Neither can any other be made to keep equal Time, that will gain and loſe all the Year agreeable to the ſaid Tables; for though the Tables themſelves may be true, yet ſome Difference in Motion does proceed, in both Sorts of Clocks, from Cold or Heat altering the Length of their *Pendulums*. This Difference, by ſome Obſervations I have made, I ſuppoſe to be about the $\frac{1}{100}$ Part of an Inch, in the Length of a *Pendulum* vibrating Seconds, which will alter the Motion of the Clock about 12 Seconds in 24 Hours. But to make my Clocks of keeping apparent Time, to go as exact as poſſible, I made a Table my ſelf by Obſervation: For obſerving the Sun, as often as it was ſeen, when it came on the Meridian, for ſeveral Years together, always ſetting down the Difference between its coming to the Meridian and the Time, by a Clock I had adjuſted as well as I could to equal Time, and always taking Notice how much my Equal-Time Clock gain'd or loſt at the End of every Year, I compleated my Table in the Year 1711. Since then I have made many of theſe Clocks: So that I think I may juſtly claim the greateſt Right to this Contrivance, of making Clocks to go with apparent Time; and I have never yet heard of any ſuch Clock ſold in *England*, but what was of my own making, though I have made of them ſo long.

Experiments and Obſervations on the Motion of Sound, by Mr. W. Derham. n. 313. p. 2.

X. 1. The Diſagreement among the moſt famous Authors, concerning the Velocity of Sound, may be ſeen at one View in the following Table, in which, in *Engliſh* Feet, the Space is exhibited, which they aſcribe to the Progreſs of a Sound in one Second of Time.

	Feet.	
Sir *Iſaac Newton*	968	Princip. Nat. Phil. L. 2. Prop. 50.
Hon. Mr. *Robarts*	1300	Phil. Tranſ. n. 209.
Hon. Mr. *Boyle*	1200	Eſſay on Languid Motion, p. 24.
Mr. *Walker*	1338	Phil. Tranſ. n. 247.
Merſennus	1474	Baliſtic. Prop. 39.
Mr. *Flamſteed* and *Halley*	1142	
Florentine Philoſophers	1148	Exp. per Acad. *del Ciment*. p. 141.
French Philoſophers	1172	*Du Hamel*, Hiſt. Acad. Reg.

There is no great Diſagreement of Opinion among the three laſt, but of the reſt there is. The Reaſon of which is manifeſtly this, either becauſe of the Inſufficiency of the Inſtruments, or becauſe of the Diſtance, or from the Winds.

1. The Inſtrument by which ſome of them have meaſured, was not a Watch or Clock, but a ſuſpended Plummet, which vibrated Seconds. But it is plain, that a Plummet is much leſs convenient, nor can be ſo accurate as a Clock; becauſe it is neceſſary that the Eye muſt firſt be employ'd in obſerving the Coruſcation, and then muſt obſerve the Plummet or Pendulum. This waſtes Times, and cauſes Confuſion. But eſpecially if,

2. The Diſtance between the Thing ſounding and the Obſerver be but ſmall. Now it is evident that moſt of theſe made their Experiments at the Diſtance of only a few Feet, and meaſured by the Return or Echo of the Sound. Some of theſe extended their Meaſure hardly beyond ſix or ſeven hundred Feet, others not above a ſingle Mile. But I have always obſerved, that in ſo ſmall a Diſtance an Uncertainty would neceſſarily ariſe, even tho' the beſt Inſtrument was made uſe of. And a very ſmall Error in ſuch ſhort Diſtances is to be accounted a great one. For perhaps the *Pendulum* has already paſs'd over half its Swing or Arch from the laſt Pulſation, when the Sound was firſt emitted. But we reckon that Pulſe as if the Vibration were fully compleat, or perhaps we anticipate the Vibration. And after the Sound has reached us, perhaps we count more or leſs than we ſhould do.

Or if the Diſtance be long enough, yet an Error may thence ariſe, if

3. We take not the Winds into our Reckoning.

Theſe are certain Inconveniencies, which attend the Menſuration of the Progreſs of Sounds.

Yet it may be obſerved, that the Spaces aſſign'd by the three laſt Obſervations of the Table, agree pretty well with one another. Doubtleſs this proceeds from hence, that the Obſervers were furniſh'd with good Clocks. In the Uſe of theſe the Ear alone is employ'd in catching the Vibrations of the *Pendulum*, while the Eye attends to the Coruſcation, or ſome other Emiſſion of the Sound. Alſo theſe Obſervations were made at great Diſtances, in which a ſmall Error could be of no great Moment. The Obſervations of *Flamſteed* and *Halley* were made at an Interval of almoſt three Miles, within a few Perches, from the Royal Obſervatory, upon *Shooter's Hill*; and the Sound return'd in 13½ Seconds of Time. The noble and celebrated *Florentines*, of the Academy *del Cimento*, made their Experiments at nearly the ſame Diſtance. And ſome at the Diſtance of one Mile only. And *Caſſini*, *Picard*, and *Roëmer* at the Diſtance of 1280 *French* Toiſes, which is more than a Mile and half *Engliſh* Meaſure.

I my ſelf have made very many Experiments, at various Diſtances, from one Mile to twelve and more. And for meaſuring of Time I have a moſt accurate Watch, with a *Pendulum* that vibrates half Seconds.

I propoſed to my ſelf to determine the following Queries.

1. How much Space a Sound paſſes through in a Second of Time, or any other Interval of Time?

2. When a Gun is diſcharged towards the Obſerver, whether it ſends its Sound in the ſame Interval of Time, as when it is diſcharged the contrary Way?

3. In every State of the Atmoſphere, when the Mercury in the Barometer aſcends or deſcends, whether Sounds deſcribe the ſame Space in the ſame Time?

4. Whether Sounds fly ſwifter in the Day-time than in the Night?

5. Whether the Sound is accelerated by a favourable Wind, or retarded when the Wind is contrary? Or how the Wind affects Sound, if it affects it at all?

6. Whether Sound moves ſwifter in calm Weather, than when the Wind blows?

7. Whether a violent Wind, blowing croſs to the Courſe of the Sound, accelerates or retards the Motion of the Sound?

8. Whether Sounds have the ſame Motion in Winter and Summer, by Day and by Night?

9. Whether they are the ſame in Snowy Weather, and in fair?

10. Whether a great and ſmall Sound have the ſame Motion?

11. Whether in all Elevations of the Gun, a Horizontal, at 10, 20, as far as 90 Degrees, the Sound arrives at the Ear of the Obſerver at the ſame Diſtance of Time?

12. Whether all Kinds of Sounds, thoſe of Guns, Bells, Hammers, and ſuch like, have the ſame Motion?

13. Whether the different Forces of Gunpowder vary the Motion of Sound?

14. Whether at the Tops of high Mountains, or in Vales, or in the higheſt and loweſt Parts of the Atmoſphere, Sounds paſs over the ſame Spaces in the ſame Intervals of Time?

15. Whether a Sound aſcending or deſcending obliquely has the ſame Motion?

tion? Or whether it aſcends from the Bottom to the Top of a Mountain with the ſame Velocity, as it deſcends from the Top to the Bottom?

16. Whether a Sound moves ſwifter at the Beginning, and ſlower towards the End, as happens to many other violent Motions?

17. Or is it not rather equable, that is, does it not deſcribe Half its Courſe in half the Time, one Fourth in a Fourth of the Time, and ſo on?

18. Has it not the ſame Motion in all Countries, Northern or Southern, in *England*, *France*, *Italy*, *Germany*, &c.

19. Does Sound paſs from Place to Place in a Right Line, or the ſhorteſt Way, or according to the Surface of the Ground between?

For determining theſe Inquiries I requeſted my Friends, that they would diſcharge Guns from Towers and other Eminencies, at the Diſtance of 1, 2, 3, as far as 8 Miles, which I found to be the greateſt Diſtance at which I could hear the Report of a Gun, in this Country which is ſo thick ſet with Trees and other Things. Theſe Guns were of great Uſe to me. But thoſe great Guns, call'd Sakers, were moſt for my Purpoſe, upon *Blackheath*, with which the young Ingeniers of the Train are there exerciſed. The Flaſhes of theſe Guns I could ſee from the Steeple of my Church, and I could hear their Report in almoſt all Weathers; nay even in the Day-time with the Help of my Teleſcope I could ſee the Flaſhes. Therefore I apply'd my ſelf with the utmoſt Care and Diligence to the Obſervation of theſe Guns, from *February* 1704-5.

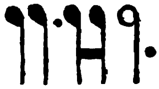
After a few Obſervations made upon theſe Explotions, I procured a certain ſpecial Experiment to be made. Two Cannons or Sakers were placed near one another, the Mouth of one of which was towards me, and of the other from me. Theſe two Pieces were diſcharged *February* 13, 1704-5, every half Hour, from Six in the Afternoon to Midnight, a gentle Gale blowing directly againſt the Sound. The Diſtance of Time between the Flaſhing of every Gun, (which I could ſee with my naked Eye,) and the coming of the Sound, was always about 120 or 122 Half-ſeconds of Time. I ſay 120 or 122, becauſe the Sound came double; that is, the firſt Sound within 120 Half-ſeconds, (which was the Fainter,) and the ſecond within 122, which was more intenſe. And in the ſame Manner during the whole Time of Obſervation, the Noiſe of every Gun came doubled.

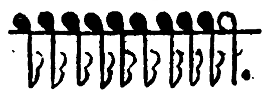
This Reduplication of the Sound to me ſeems an Echo, which was reflected, as I imagine, by the Mill upon *Blackheath*, or by the neighbouring Houſes. Of which I ſhould have no Reaſon to doubt, if it was not for the Opinion of a certain learned Friend, who believes that no Echo can be heard, but which is made by reflecting Objects not far from the Obſerver, and not by thoſe which are near the ſonorous Body, or other diſtant Objects.

Of an Echo at a great Diſtance. 2. But this I think not to be contrary to the Nature of an Echo. Then it is to be obſerved, that this double Sound came directly from *Blackheath*. Nor did the firſt Sound come from thence, and the other (like an Echo) from elſewhere, either beyond me, from the Right Hand or Left, or from any other Side. And the ſame Thing I have frequently obſerved, when great Guns were diſcharged from the Ships in the River *Thames*, eſpecially if the

Air was calm and ſerene, either in the Evening or Morning, when thoſe they call the *Watch-guns* were diſcharged. After the Sound of the Gun had reached the Ear, I heard it ſtill running along the River, and echoing from the Shores, the Hills, and the Rocks, (which are in great Plenty along the *Kentiſh* Shore) and that for many Miles together.

All theſe Things, according to my Friend's Opinion, proceeded from the Repercuſſion of the Houſes and other Objects that were near me. But to ſay nothing of the Weakneſs of the Sound, after it has paſs'd on for ſeveral Miles, and of its Incapacity to produce ſuch an Effect, if it had come ſo far, and was then repell'd by reflecting Objects near the Obſerver, rather than by reflecting Objects that were near the ſonorous Body; I ſhall give an Example or two, whence it will appear, that an Echo made by reflecting Objects near the ſounding Body may be heard for ſeveral Miles, as well as the primary Sound, and ſometimes more intenſely than the ſame.

I have often obſerved, that Cannons diſcharged in the Evening on the River *Thames*, about *Deptford* and *Cuckbold's-Point*, often made a Report which was double, treble, four-fold, and ſtill more multiply'd; and that the later Reports are ſtill the louder. And when I have gone croſs-wiſe this Way or that Way perhaps a Furlong, or a Quarter or Half a Mile, yet ſtill the Sound was the ſame. I remember that on the 8th of *March* laſt paſt, ſeveral great Guns were diſcharged ſome where between *Deptford* and *Cuckbold's-Point* aforeſaid, from a Ship which I then ſaw upon the *Thames* from my Church. Their Sound was repeated five or ſix Times, after this Manner, . I counted 122 Half-ſeconds between the Flaſh and the Sound, the Wind blowing obliquely. Therefore at that Time the Guns were diſtant from me above 13 Miles. The two firſt Cracks were fainter than the third; but the laſt Cracks were louder than any of the reſt. And going a Quarter of a Mile to my Right Hand, the multiply'd Sound was the ſame, and likewiſe when I went to my Left Hand. And beſides in ſome of my Stations, beſides the multiply'd Sound, I plainly heard a faint Echo, which was reflected by my Church and the Houſes adjacent: Which I obſerved then very often, when ever the Guns were diſcharged.

Another Obſervation of a like Kind was made on a certain *Sunday*, about two or three Years ago, on the Sound of a large Cannon diſcharged ſomewhere in the River *Thames*, on this Side or beyond the Town of *Graveſend*. The Sound of this Gun was multiply'd at leaſt eight, nine, or ten Times, according to this Meaſure of this Time . Many thought this multiply'd Sound was the Noiſe of many Guns belonging to the Ship; but I conceive it to be nothing elſe but a reiterated Echo, from the Sound of one or two Guns, which was reverberated from ſeveral Ships, or the neighbouring Shore. I did not only hear this my ſelf, but many others who were far off. Mr. *Barrett* heard the ſame repeated Sound at his own Houſe, which is near four Miles diſtant from *Upminſter* where I heard it.

Of an Echo *in the* Air.

3. I will add an Example alſo of the Repercuſſion of Sound in the Air, by Aerial Particles.

When I heard the Reports of great Guns, eſpecially when the Air was calm and ſerene, I often obſerved Murmuring to go before the Crack, in the Air above. And in a thin Cloud, I often heard the Sound of Guns above, juſt over my Head, which ran along for ſeveral Miles in the Air; ſo that this Murmuring continued for 15 Seconds of Time. This continual Murmuring, in my Judgment, proceeds from Particles of Vapour ſuſpended in the Atmoſphere, which oppoſe the Courſe of the Undulations of Sounds, and beat them back to the Ears of the Obſerver, after the Manner of an indefinite Number of Echos; which we call a Murmuring in the Air.

Theſe Things being duly conſider'd, it will be evident that an Echo may be heard which is made a far off; and that the aforeſaid Reduplication of the Report of the Guns upon *Blackheath* proceeded without doubt from *Blackheath* it ſelf, as I juſt now affirm'd.

No Variation *of* Sound *from the* Different *Elevation, or Direction of the* Gun.

4. Now to go on to my Obſervations concerning the Progreſs of Sounds. What I have ſuggeſted about the Sound of the Guns at *Blackheath*, I have found to be true in all others; that the Motion of Sound is neither ſwifter or ſlower, whether the Gun be diſcharged towards the Obſerver or from him.

Alſo in all Poſitions of the Gun, Horizontal, or upright, and in all Elevations of the ſame, whether 10 Degrees, or 20, &c. there is no Variation of the Sound. So true is the Obſervation of the famous *Florentine* Academy *del Cimento* in this Matter.

Alſo the Force of Gunpowder, whether ſtrong or weak, a greater or a ſmaller Quantity, tho' it may increaſe or leſſen the Intenſity of the Sound, yet it neither accelerates or retards its Motion.

The Motion *of* Sound *not* alter'd *by the* Alterations *in the* Air.

5. *Kircher* affirms, that he always found a different Velocity of Sound, at different Times, in the Morning, at Noon, in the Evening, in the Night-Time. But as I had the Convenience of a better Time-keeper, and a more commodious Diſtance, I never found there was any Diverſity in the Motion of Sound at theſe Seaſons. But in all Kinds of Weather, whether the Sky was clear and ſerene, or cloudy and turbid; whether Snow fell, or it was miſty; (for both of theſe ſtrongly abate the Audibility of Sound,) whether it Thunders or Lightens, whether it be Hot or Cold, Day or Night, Summer or Winter; whether the Mercury in the Barometer aſcends or deſcends. In all Changes of the Atmoſphere whatever, (Winds only excepted,) the Motion of Sound is neither faſter or ſlower, but is only more or leſs loud from that Variety of the Medium; which perhaps has deceived the ſagacious *Kircher*.

Hence it will follow, that the Concluſions are erroneous, which *Walker* has deduced from the Obſervations of Dr. *Plot*, *Kircher*, and thoſe of his own.

Sounds *produced from* different *Bodies* move *with the ſame Velo-*

6. Though *Kircher* is of a contrary Opinion, yet I do not at all doubt but that the Sounds of all Bodies, of Guns, Bells, Hammers, &c. have the ſame

Velocity. In the Year 1704, I compared together the Beats of a Hammer and the Report of a Gun, at the Diſtance of a Mile, which is the fartheſt that I could hear the Sound of the Hammer; and I found that the Sound of both came to me in the ſame Time. And that they paſs'd $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ of the ſame Space in $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ of the ſame Time.

As for what belongs to intenſe and languid Sounds, I doubt not but that they paſs over the ſame Space in the ſame Interval of Time; as may partly appear from theſe Experiments.

Jan. 13, 1704-5, The Maſter Gunner of *Tilbury Fort*, at my Requeſt, diſcharged a Gun or two, and a great Mortar in which he ram'd the Gunpowder very well. The Noiſe of all theſe came to me in the ſame Time, being diſtant about three Miles.

Alſo *Sept.* 11, 1705, the Head Gunner of *England*, on my Account, upon *Black-Heath* after Sun-ſet, diſcharged ſome Muskets, Sakers, and Mortars. The Muskets I could not hear, becauſe of the great Diſtance, or becauſe the Air was not very clear. But I heard the Sound of the Sakers and Mortars in the ſame Interval of Time, tho' the Noiſe of the Mortars was much more dull and remiſs than that of the Sakers.

The Motion of Sound uniform.

7. As to the Equability of the Motion of Sounds, I found it to be ſo as the Academy *del Cimento* had determin'd long ago. That Sounds paſs half their Space in Half the Time, a fourth Part in a fourth Part of the Time, and ſo on. Which will appear from the Examples in the following Table.

The Place in which the Diſcharge was made.	The Number of the Vibrations of the *Pendulum.*	The Diſtance of Places. Trigonometrically	The Diſtance of Places. By the Sound.	The Courſe of the Winds.
		Miles.	Miles.	
The Church at *Hornchurch*	9	0, 9875		Oblique.
North Okendon Church	$18\frac{1}{2}$	2, 004	2, 0	Oblique.
Upminſter Mill	$22\frac{1}{2}$	2, 4	2, 4	Favourable.
	23		2, 48	With Snow, oblique.
Little Warley Church	$27\frac{1}{2}$	3, 0	2, 97	A ſtrong fair Wind.
Rainham Church	$33\frac{1}{4}$	3, 58	3, 59	Oblique.
Alveley Mill	33	3, 58	3, 57	Oblique.
Dagenham Church	35	3, 85	3, 78	Favourable.
South Weal Church	45	4, 59	4, 86	Oblique.
Eaſt-Thorndon Church	$46\frac{1}{2}$	5, 09	5, 03	Little favourable.
Barking Church	$70\frac{1}{2}$	7, 7	7, 62	Favourable.
Blackheath Guns	116	12, 5	12, 55	Oblique.

The Diſtances of Places from *Upminſter*, (the Place in which I obſerved) as ſet down in this Table, were meaſured with all the Exactneſs I was able, either by a meaſuring Rod, or by Trigonometry. And from the great Agreement there is found between the Diſtances meaſured in this Manner, and likewiſe by the Motion of Sound, the Excellence of my Inſtruments, as alſo the Truth of my Obſervations and Calculations, appear very plainly. For the Difference between the Diſtances meaſured, and the ſame taken by Sound, is either none at all, or only a few hundredth Parts, unleſs when the Wind was fair (excepting that at the Church of *South Weal*, of which I ſhall ſpeak afterwards.) Thus in the Obſervations made from the Churches of *Dagenham*, *Warley*, *Thorndon*, and *Barking*, the Diſtances taken from the Sound ſeem ſomething ſhorter than they ſhould be, becauſe the Wind accelerated the Sound. But in forming this Column of Diſtances by the Sound, I allow'd nothing for the Acceleration of the Winds; but I only divided the Number of Vibrations, or of Half-ſeconds, by $9\frac{1}{4}$ or 9,25, the Number of Semi-ſeconds in which Sound deſcribes one Mile.

Alſo the Equability of the Motion of Sound is evident from this Table; as will appear from comparing the Vibrations and the Diſtances, or from the Column of Diſtances from the Sound only.

Now that nothing might be wanting for the Confirmation of this Matter, I made a Journey to the Sands at *Foulneſs* on our *Eſſex* Shore. Theſe Sands, which are continually cover'd and waſh'd over by every Day's Tide, make a large and exact Plain of many Miles. Upon this Plain I meaſured out only ſix Miles; for neither the Tide nor my own Time would permit me to make Uſe of a longer Diſtance. At the End almoſt of every Mile I made Experiments by diſcharging Guns. From which Experiments I found, that all my former Obſervations were juſt and true; that is, that Sound paſſes a Mile in

$9\frac{1}{4}$ Half-Seconds, two Miles in $18\frac{1}{2}$ Half-Seconds, three Miles in $27\frac{3}{4}$ Half-Seconds, and ſo on.

Of the Aſcending *and* Deſcending *of* Sounds, &c.

8. As to the 15 and 19 Queries, I confeſs I could never ſatisfy myſelf in theſe Matters, by any of the Experiments I made.

And firſt as to the Progreſs of Sound by the ſhorteſt Way, as in Query 19. The Reaſon of my doubting of this was the Difference between the Space between the Village of *Weal* and *Upminſter* meaſured Trigonometrically and by the Sound, as exhibited in the foregoing Table. The Trigonometrical Menſuration was taken in ſo many Manners, and with ſuch good Angles, that I could have no Scruple about it. But becauſe by the Motion of the Sound the Diſtance ſeems greater, and the Superficies of the intermediate Soil puts on ſuch a Figure as is exhibited in *Fig.* 175; therefore I had ſome Suſpicion whether the Sound might not move with a crooked Motion? or whether the Acclivity intervening in A might not oppoſe the Undulations of the Sound, and thereby retard it.

Fig. 175.

That I might ſomehow untye this Knot, I cauſed an Experiment to be made, by the Sound of a Gun from the Top of *Langdown* Hills into the Valley beneath, at the Diſtance of 3,79 Miles. The Interval was carefully meaſured Trigonometrically, by Means of Angles and a Baſe that was large enough; and the Experiment was made when a gentle Gale a little oppoſed the Sound. I counted $35\frac{1}{2}$ Half-Seconds between the Flaſh and the Report; which Number ſo well agrees with the Diſtance, and approaches ſo near to the other Experiments, that there can be no Doubt but that Sound deſcends from the Top of a Hill ſtrait down into the Vale beneath, (through the Air) and not according to the uneven Surface of the intermediate Ground.

Therefore I imagine there was ſome Error in the foregoing Obſervations at *Weal*, becauſe I have not obſerved any ſuch Thing, either in the laſt Experiment at *Langdown*, nor in any other.

As to the Motion of Sound up and down; that is, whether it is carried after the ſame Manner, and in the ſame Degree, from the Top of a Mountain to the Bottom, and back again? I can hardly hope to ſatisfy myſelf or any other in this Matter. Here in *Eſſex* and the Parts adjacent we have no Hills high enough to make the Experiments requiſite for this Purpoſe. For the higheſt of all I have yet ſeen, ſuch as thoſe call'd *Langdown Hills*, do not much exceed Half a Furlong. For I have meaſured the higheſt Summit of the ſame, both Trigonometrically as alſo with my portable Barometer, and find the ſame by the firſt Method to be 363 Feet high.

But the laſt Summer, when I took a Journey to the Weſtern Coaſts of the Kingdom, I had a Mind to try from a certain Hill, the Height of which I meaſured a few Years ago, and found it, (if my Memory fails me not) to be about three Furlongs. At which Time the Wind blew obliquely, but ſo gently, that it would hardly have extinguiſh'd a lighted Candle. Then I order'd ſome Muskets to be diſcharged at the Foot of the Hill and at the Top, and I found the Sound to come both Ways nearly in the ſame Space of Time: If there was any ſmall Difference it ſeem'd to conſiſt in this, that the Sound aſcended ſomething ſooner up the Mountain than it deſcended down the ſame.

But I could hardly meaſure the Time with the Exactneſs that was neceſſary, becauſe it happen'd unluckily, that my Time-keeper was a little out of Order by the Carriage. Therefore I muſt leave this Experiment to be made by others with better Succeſs. And indeed I could wiſh it might be tried at the *Alpes*.

Motion of ***Sounds in*** **Italy.** 9. Some Obſervations and Experiments made at my Deſire in *Italy*, by the moſt learned Dr. *Newton*.

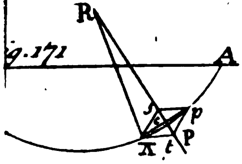
Richard Townley, Eſq; inform'd me by Letter, *An.* 1704, " That Sounds " were ſeldom heard at *Rome* ſo far as in *England*, and in our Northern Cli- " mates. Particularly he ſaid, that while he was at *Rome* ſome Guns were " diſcharged at the Caſtle of St. *Angelo*, while he was upon Mount *Trinidad*, " and that he obſerved the Sound was much more languid in that Place, than " in any other at the ſame Diſtance. And after his Death his Brother wrote " to me, that in the Year 1688, leaving *Rome* he came to the Caſtle " *Gendolphe*, (being a higher Situation near the Lake *Albanus*, about twelve " *Italian* Miles from *Rome*) he obſerved the Sound of great Guns diſcharged " from the aforeſaid Caſtle St. *Angelo*, which ſeem'd to him to be very weak " and faint. Alſo at another Time, when his Chariot paſs'd near the Walls " of the aforeſaid Caſtle, and great Guns were diſcharged from thence, they " did not ſeem to make ſo loud a Noiſe there as he expected.

As this was obſerved by theſe two Gentlemen, and the Phenomenon itſelf ſeem'd to be new and unknown before, I had a great Mind to enquire into the Cauſe of it. Therefore I wrote a Letter to the learned Dr. *Newton*, who ſent me Word back in *October* 1706, what himſelf and his Friends had obſerved about it.

He tells me, that in his Journey from *Bononia* towards *Florence*, at the City of St. *Michael* in *Boſco* (near *Bononia*) he heard the Report of Guns that were diſcharged; which Guns were diſcharged at *Mirandula*, and were diſtant 40 Miles: For at that Time the *French* Army were then beſieging this Place. And the Night following lodging upon the *Apennines*, being 20 Miles farther off, he heard the ſame Sound.

When he received my Letter at *Florence*, he acquainted a certain Nobleman with the Contents, who afterwards communicated my Requeſt to the Great Duke. He ſays, " The Great Duke immediately gave Orders, that " Experiments might be made for my full Satisfaction." He appointed *Joſeph Averrani*, a noted Philoſopher at *Piſa*, to ſupervise and direct theſe Experiments. The Reſult was this.

" In the lower Tower at *Florence* a great Gun was often diſcharged between " the Hours of One and Three at Night, and certain Men at *Leghorn* were " appointed, to obſerve diligently whether they could hear the Report. Some " of theſe who were placed at *Lanterna* and *Marzocco* did not hear it; poſſibly " becauſe the Claſhing of the Waves of the Sea might diſturb the Sound. " But others who ſtood upon the Fortifications of the old Tower, which is " call'd *Denjon*, and thoſe that were ſent to that call'd *Mount Rotondo*, (which " is about five Miles diſtant from *Leghorn* towards *Mount Nero*) could hear " it well enough. And as often as it was diſcharged, ſo often the Report


ig. 171

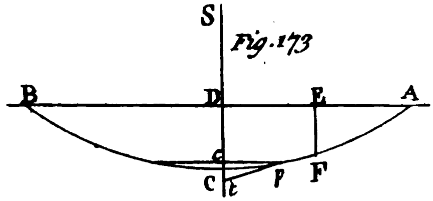


Fig. 173

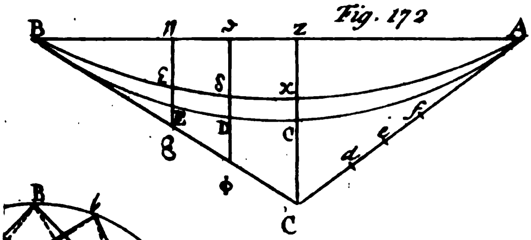


Fig. 172

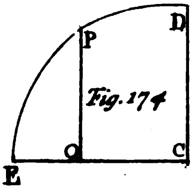
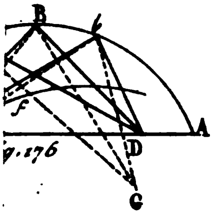


Fig. 174


ig. 176

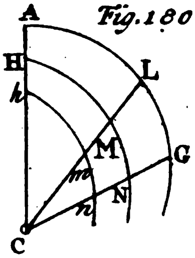


Fig. 180

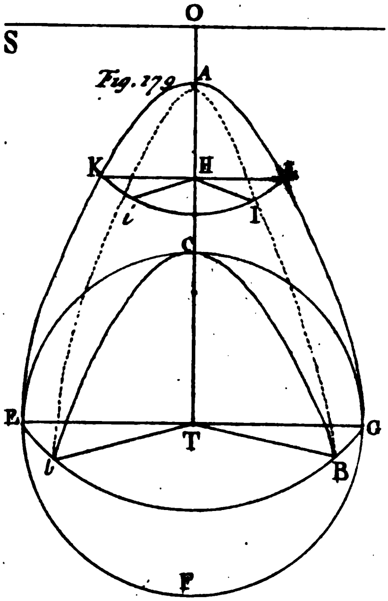


Fig. 179

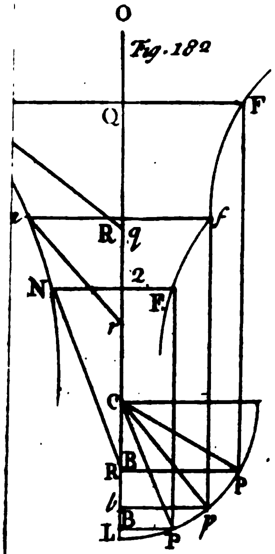


Fig. 182

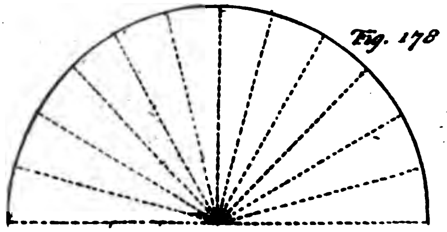


Fig. 178

" was plainly heard in thoſe Places. Now the Diſtance of this *Florentine* " Tower from *Mount Rotondo* in a right Line, is thought to be not leſs than " 55 Miles. And it is worth obſerving, that the intermediate Country " abounds with Hills, which of Neceſſity muſt ſomething impede the Paſ- " ſage of the Sound. To which may be added, that the ſame Evening there " was a moderate Weſterly Wind, which may be fairly ſuppoſed to hinder " ſomething the Expanſion of the Sound, ſince *Legborn* is ſituate to the South- " Weſt in reſpect of *Florence*.

" Now that an open Place might be had, that Tract of Sea was made " Choice of, that lies between *Legborn* and that call'd *Porto Ferraio*, the Di- " ſtance of which is found to be 60 Miles, according to the Calculation of " ſkilful Navigators. And the Sound of Guns of War is often heard from " *Legborn* to the aforeſaid *Porto Ferraio*, and the neighbouring Places; nor " is there any Occaſion for the Aſſiſtance of a fair Wind, to help the Pro- " greſs of the Sound, that it may be heard the better. For any Wind what- " ever, whether for it or againſt it, is a Hindrance to Sound, and makes it leſs " ſonorous. Perhaps becauſe the Noiſe that is thence made in the Sea is a " greater Impediment, than the Courſe of the Air ruſhing thither would be " an Aſſiſtance. Wherefore the Sound is then only heard, when the Wind " is quite ſtill, or whiſpers very ſoftly, and when the Air is ſerene, and the " Sea calm. Neither even then is it heard indifferently from all Places, but " only from thoſe which are ſomething lofty; ſuch are thoſe two Forts which " are call'd the *Star* and the *Falcon*, and the Place call'd *Mulini*. Beſides, it " is neceſſary that the Obſerver ſhould keep himſelf very attentive, nor ſhould " be incumber'd with the Noiſe of any near him. And then he may hear as " well by Day as Night, if the Atmoſphere be ſerene and calm; except that " in the Night-time Sound ſeems to be ſomething ſtronger and ſharper, when " no other Noiſes mix with it, which by Day continually aſſault the Ears.

" It has alſo been told us by Witneſſes very deſerving of Credit, that many " Years ago, when there were Tumults at *Meſſina*, and the City itſelf was " beſieged, that the Reports of the great Guns reached the Ears of the Inha- " bitants of *Auguſta* and *Syracuſe*.

" Likewiſe when the *French* bombarded *Genoa*, it is certain that the Sound " reach'd as far as the *Black Mountain*, which is near *Legora*.

" From theſe Obſervations we are inclined to believe, that there is no Dif- " ference in this Matter between *Italy* and the Northern Climates.

" As to the other Query, Whether a Wind that blows with or againſt a " Sound accelerates or retards its Motion? As yet we cannot anſwer this " with any Certainty. Yet we will produce the following Experiments.

" A great Gun (60) was planted upon the Curtain of the lower Fort at " *Florence*, and ſo fixt, that its Mouth might be directed towards *Artemino*, " which is a Country Palace of the Great Duke of *Tuſcany*, ſtanding upon a " pretty high Hill, looking towards the Weſtern-ſide of the ſaid Fort, from " whence it is diſtant about 12 Miles. We choſe a Day when a Weſterly " Wind blew pretty ſtrong, that the Motion of the Sound might be hin- " der'd by the oppoſite Wind. But this was of little Uſe, for at Evening the Air was quite calm, or at moſt had ſo little Motion, that it would hardly diſſipate the Flame of a lighted Candle. Then leaving ſome ſkilful Perſons here, we retired to the aforeſaid Palace *Artemino*, and between the firſt and third Hours of the Night, the Cannon was diſcharged ſeveral Times; and we conſtantly counted 49 Seconds between the Flaſhing and the Report. And we alſo at *Artemino* fired ſome Bombs, between the Flaſhing and Report of which the Obſervers aforeſaid, which we left behind in the Fort, counted only 48 Seconds. Whence it appear'd, that the Sound went ſwifter from *Artemino* to *Florence* by only one Second, than the contrary Way.

“ We dare not truſt our Obſervation ſo much as to affirm, that this little Difference of Velocity muſt be imputed to the Force of conſpiring or oppoſite Wind. For poſſibly it may ariſe from the Miſtake of the Obſerver, who counted the Vibrations of the *Pendulum*, which may eaſily happen. It may ſo fall out, that he may not ſee the Flaſh till after the Vibration of the *Pendulum* was begun, or may hear the Sound before the Vibration is compleated; ſo that by this Means he may make his Reckoning one more than it ſhould be, whilſt the Space of Time in both Caſes is the ſame.

“ When it was Day we order'd the Gun to be diſcharged again; but the Wind was neither favourable to our Work or our Wiſhes. For a little before it had gone about to the North. So that the Difference of the Time and of the Velocity of the Sound could hardly be perceived in ſo ſmall a Change of the Wind: So that we counted 49 Vibrations of the *Pendulum*, as before.

As to the Space, which Sounds paſs over in any given Time, they are not yet ſatisfied about this Matter; but from ſome Experiments they apprehend it to be, as has been determin'd by the Experiments of the Academy *del Cimento*.

From theſe Obſervations it abundantly appears, that Sounds may be heard much farther in *Italy* than my aforeſaid ingenious Friend has inform'd us. For the excellent Dr. *Newton* has heard the Exploſion of great Guns at the Diſtance of 60 Miles. Thoſe that were diſcharged at *Florence* at his Requeſt, were heard 55 Miles. The Guns diſcharged at *Leghorn* were heard at the Diſtance of 60 Miles. Thoſe diſcharged at *Meſſina* were heard by ſome at nearly the Diſtance of 100 *Italian* Miles, as appears by the Maps. Thoſe diſcharged at the Siege of *Genoa* were heard at above 90 Miles by the Maps.

All which Things conſider'd, I cannot but think, that Sounds are as freely propagated in the Southern Countries as in theſe to the North. Though Examples are not wanting of a farther Progreſs of Sounds in ſome Northern Countries of the Earth. A certain *Dane* aſſured me, that when he lived in *Denmark* he heard very plainly the Sound of ſome Bombs, which were diſcharged at *Carelſcroon*, when he was diſtant 80 Miles, if I rightly remember. The very ſkilful Dr. *Hearn*, Phyſician to the King of *Sweden*, ſent an Account to our Royal Society concerning great Guns diſcharged at *Ulm*, *A. D.* 1685;

the Noiſe of which travel'd 30 *Swediſh* Miles, which are nearly equal to 180 *Engliſh* Miles. Alſo in that Sea-fight between *England* and *Holland*, *A. D.* 1672, the Noiſe of the Men of Wars Guns was heard by ſome that were diſtant above 200 Miles: For it paſs'd over our Iſland as far as *Shropſhire* and *Wales*.

Therefore what was obſerved by the two Brothers *Townleys*, is peculiar to the foreſaid Caſtle of St. *Angelo*, or at leaſt to *Rome*. That Diminution of Sound, which they took Notice of, muſt be owing either to the Situation of the aforeſaid Caſtle, or to the intermediate Houſes riſing high and unequally in that City, or to the foreign Noiſes intermingling, or to contrary Winds, or to ſome other Cauſe of a like Nature: Or perhaps they made their Obſervations in ſuch a Conſtitution of the Air, in which Sounds are much more faint, even though they have favourable Winds, than at other Times when they are quite contrary.

Of the Remiſſneſs *and* Intenſeneſs *of* Sounds, *according to the* Alteration *of the* Air.

10. I have often obſerved in Summer, when the Air was hot, that Sounds ſeem'd to be fainter than uſual, and to come very weak to our Ears; whereas in another Seaſon, eſpecially in Winter in froſty Weather, they were much more ſhrill and ſtrong. Alſo when the North or Eaſt Winds blew, though the contrary Way, I perceived Sounds to be lowder than when the Winds came from the contrary Quarters. This *Kircher* alſo took Notice of at *Rome*; tho' it is not conſtant and perpetual.

Nor could I conclude any Thing with more Certainty, from the Inſpection of the Quickſilver aſcending or deſcending in the Barometer. For ſometimes when it roſe to the very Top, Sounds were louder and ſtronger, and ſometimes weaker. When on the contrary they were more noiſy, when the Mercury fell to the Bottom.

There is a like Uncertainty when the Air is ſerene or cloudy. In rainy and moiſt Weather I have often obſerved that Sounds were blunt and dull. But after Showers that were violent, they have acquired much Strength, as *Kircher* has obſerved at *Rome*. But the Contrary alſo has often happen'd. *May* 31, 1705, the Air was here much clearer and freer from Vapours than ever I remember to have ſeen it before. The Sky was ſo very clear and limpid, that I could eaſily perceive the moſt diſtant Objects. Yet I could not hear the great Guns which were then diſcharged on *Blackheath*, (excepting one, whoſe Report I heard but very faintly) though I could eaſily ſee the Flaſh of every one. And at the ſame Time the Motion of the Clouds and Wind conſpired with that of the Sound. For a very mild Air then breathed, and every Thing then ſeem'd to concur to aſſiſt the Sound. And on the contrary, when the Conſtitution of the Air and Heavens was entirely changed, when all Things were turbid, and the Atmoſphere was full of Vapours, I have obſerved that Sounds were loud, and as often dull and heavy.

I muſt leave the Cauſes of theſe Variations to be enquired into by others, becauſe I confeſs they are as far above my Capacity as it is to aſſign what is the proper *Medium* or Vehicle of Sound. Whether it be the purer and more ethereal Part of the Air, or the denſer and more vaporous Part, or both together?

As to what concerns groſs Clouds, it is certain they very much blunt and deaden Sounds; for then Sounds ſeem to be generally very languid and dull. This certainly ariſes from thoſe groſs Vapours and cloſe Particles that conſtitute a Cloud.

The ſame I have obſerved of ſnowy Weather: For when Snow has juſt fallen upon the Ground, Sounds immediately grow dull. But as ſoon as its Superficies becomes frozen and icy, they are again more ſhrill and ſtridulous. I have heard Bells and Guns tinkling and bellowing as loud as before the Snow fell. Mr. *Townley* lately aſſured me, he had obſerved, (as indeed I have taken Notice of myſelf) as he was riding on Horſeback through ſome Town, that the Noiſe of the Bells, which were ringing not far off, could hardly be heard by him when a Houſe cover'd with Snow interpoſed. So that entering the Town, he very much wonder'd to find the Bells ſtop on a ſudden, as he paſs'd by ſome Houſes between, and again to ring out when he came to a Vacuity free from Houſes. And this he obſerved all the Way paſſing through the Town, that the Noiſe of the Bells came to his Ears or not, according as the Buildings did or did not interpoſe.

Of the Influence of Winds *on the* Motion *of* Sounds.

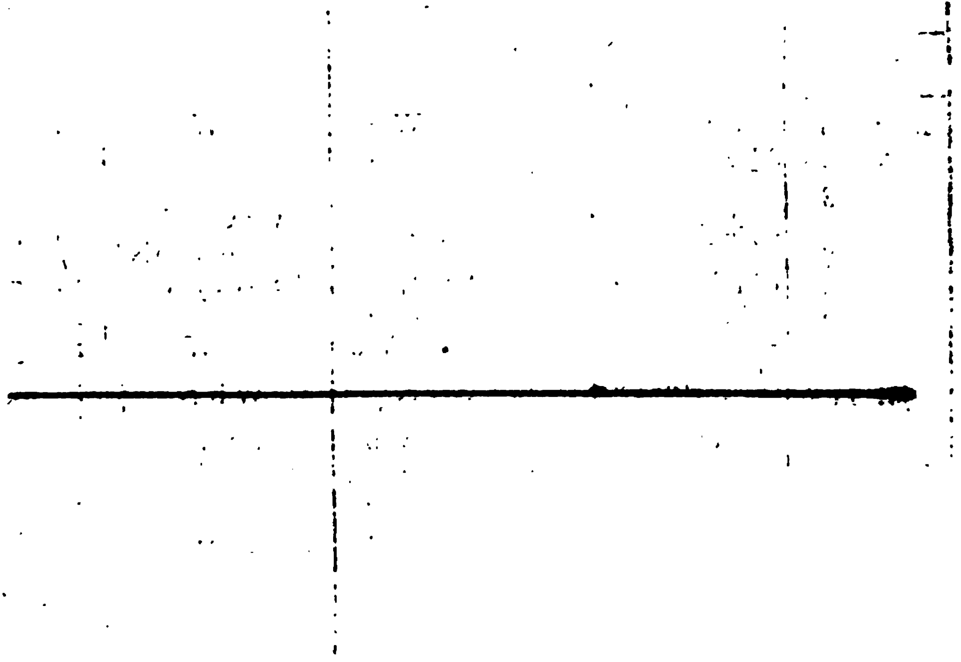
11. The moſt illuſtrious Academy *del Cimento* found by Experiment, that the Motion of Sounds was not hinder'd by contrary Winds, nor promoted by fair Winds. But that however the Winds blew, the ſame Space was always deſcribed in the ſame Time. *Gaſſendus* was of the ſame Opinion and almoſt all other Philoſophers.

Yet for all that, the Contrary appears from Experience. They ſeem to have fallen into this Miſtake, becauſe they made their Experiments at too ſhort a Diſtance: For it is very probable that theſe Philoſophers made their Obſervations from the Diſtance of one Mile only, or two or three at the moſt: Therefore it cannot be wonder'd at, that they are ſo faulty. But if they had tried with good Inſtruments, at ten or twelve Miles, which I have often done, they would ſoon have perceived their Error.

I myſelf have often fallen into this common Miſtake, ſeduced by the Authority of theſe Gentlemen; till after the Obſervation of great Guns upon *Blackheath*, for three Years and more, I at laſt very happily diſcover'd and retracted it. Now when firſt I perceived that Sounds arrived at my Ears ſometimes ſooner and ſometimes later, I entertain'd a Suſpicion that I muſt have made ſome Miſtake; either that I had miſcounted the Vibrations of my *Pendulum*, or had not rightly obſerved the Flaſh of the Powder, or had fallen into ſome other Error of the like Kind. But when the Guns were diſcharged on Purpoſe for me, every Half Hour, from Six a-Clock to Midnight, and I found the Sound to come always without any notable Variation,

riation, in the Space of 120 or 122 Half-Seconds, even though the Wind was quite contrary; and at other Times when the Wind was fair, whether direct, or a-croſs, or oblique, the Sound of the ſame Guns was obſerved to come in the Space of 111, 112, 113, 114, 115, 116, or at moſt 117 Semi-Seconds: Then I was fully perſuaded that there was ſome material Difference, which produced that Variety in the Obſervations.

Nor do fair or foul Winds only accelerate or retard the Motion of Sounds, but alſo according to their various Degrees, whether they blow more vehemently or more gently, ſo much the more or leſs they promote or hinder. Concerning which I ſhall ſubjoin ſome particular Obſervations in the following Table. Firſt taking Notice, that the Guns upon *Blackheath* are diſtant from the South about 60 Degrees; that is, that they decline to a Point ſomething more remote from S W b S.



A Table of the Sounds *of great Guns upon* Blackheath, *according to the Variety of Winds, and Forces, with which they are agitated.*

The Day of the Month and Year.	The Hour of the Day.	The Numb. of Vibrations	The Point of the Wind.	The Courſe of the Clouds.	The Height of the Mercury.
1704.					
Feb. 13	The 6 Hour.	120	N E b E 1	N E b E	29 99
	At Midnight.	122			
21	At 11½ Morn.	119	E 2	E	30 22
1705.					
Mar. 30	10 in the Morn.	113	S W 7	S W	29 30
Apr. 2	8½ Afternoon.	114½	S b W 1		
3					
3	10 in the Morn.	116½	S 4	Lower Clouds S Up. ditto W b N	29 80
5	1 in the Aftern.	111	S W b W 7	S W by W	29 70
13	8½ in the Morn.	120	N b E 2		29 26
24	5 Afternoon.	116	S W b W 0	N W	29 59
Sept. 11	6½ Afternoon.	115	W 2	W b N	Saker.
	7 Afternoon.	115½	W b N 2		Mortar.
29	10½ Morning.	112	S S W 6	S S W	29 38
Octob. 6	10 in the Morn.	117	E S E 1 & 2	S E	29 34
Nov. 30	At Noon.	115	S S W 4	S S W	29 10
Febr. 15	11 in the Morn.	116	S b W 1	S W	29 60
1706.					
Nov. 29	11½ Morn.	116	S W 0	S W b W	30 06
	At Noon.	118	S W b S 1		
Febr. 7	At Noon.	113	S W b W 4	W	29 83

I have choſe theſe Obſervations out of many, which were all carefully made, and repeated twice, thrice, or oftner. Thus from the Experiments made *April* 5, and *Sept.* 29, it appears, that violent Winds preſs forwards and haſten Sounds. For on *April* 5, when the Motions of the Wind and Sound nearly conſpired together, and the Wind was pretty ſtrong, (as is denoted by the Figure annexed [7] and in the ſame Manner the Cipher [0] denotes a calm Air, and the Figures 1, 2, 3, 4, *&c.* ſignify the various Strength of the Wind) at that Time, I ſay, the Sound travel'd its Journey in the Space of 111 Semi-ſeconds. But on *April* 24, when the Wind blew the ſame Way, and the Air was calm, it perform'd the ſame Journey in the Space of 116 Semi-ſeconds. So *Feb.* 7, 1706, when the Wind blew from the ſame Quarter, and brought the Sound along with it, but with a Strength that was not above Half as much, there paſs'd 113 Semi-ſeconds before the Sound compleated its Journey. So again *Sept.* 29, 1705, the Wind blowing pretty ſtrong, and not ſo fair, the Sound perform'd its Courſe within 112 Semi-ſeconds. From which, and from the other Examples in the Table, it plainly appears, that ſtrong Winds aſſiſt the Propagation of Sound, and that weak ones do not promote it ſo much.

The ſame is evident alſo from thoſe Winds, or Torrents of Air, which directly favour or hinder the Progreſs of Sound; that is, that they make its Motion either ſwifter or ſlower. And thoſe Fluxions of the Atmoſphere which are intermediate, in like Manner cauſe an intermediate Progreſs of Sound, or make an intermediate Number of Vibrations of the *Pendulum.*

The greateſt Difference which I have yet obſerved, in the Progreſs of Sound, for the Space of almoſt 13 Miles, is equal to about nine or ten Half-ſeconds, and that is when ſtrong Winds help the Sound, and gentle ones only hinder it. But when thoſe that promote or obſtruct are very mild or none at all, then the Difference hardly exceeds two or three Half-ſeconds.

Of the Velocity *of* Winds.

12. That I might know to a Certainty how much Space is paſs'd over by Winds in any aſſign'd Time, I made Uſe of certain light Bodies in my Experiments, ſuch as Down, ſoft Feathers, *&c.* which ſeem'd to be better adapted to the Purpoſe than that Inſtrument, which is deſcribed in the *Philoſophical Tranſactions*, n. 24, or that other more convenient one in the Shape of a Windmill, invented (if I miſtake not) by the the moſt ingenious Dr. *Hook.*

Vid. ſupra, V. 11. c. 1. S. XVII.

From the many Experiments which I have made, by the Help of thoſe light Bodies, when the Strength of the Wind was very different, I found that the moſt vehement Wind hardly paſs'd over ſixty Miles in the Space of an Hour. For Example, *Auguſt* 11, 1705, there was ſuch a Storm of Wind, that it almoſt overturn'd the Windmill itſelf, near the Place where I made my Obſervations. [I generally denoted the Force of the Wind, as I have ſaid already, by the Figures, 0, 1, 2, 3, *&c.* as far as 10 or 15, or more Degrees.] I eſtimated the Force of the aforeſaid Wind to anſwer to about 12 or 14 of theſe Degrees; and obſerved from many repeated Experiments, that that Whirlwind deſcribed about 33 Feet in the Space of one Half-ſecond, or 45 Miles in an Hour. Whence I collect, that the moſt furious and moſt ſtormy Wind, not excepting that Tempeſt which raged in *November*, 1703, does not paſs above fifty or ſixty Miles in the Space of an Hour.

Having thus meaſured the Velocity of the moſt rapid Winds, it will not be difficult to gueſs what is the Velocity of thoſe which are leſs violent: For I have obſerved their Courſes alſo, and am certified by various Experiments, that ſome of theſe traverſe fifteen Miles in an Hour, ſome thirteen, ſome much more, and ſome much leſs. Some creep with ſo ſlow a Motion, that they hardly go a Mile an Hour. Again, ſome Winds move ſo very ſlow, that a Man on Foot or on Horſeback may eaſily overgo them. This appears to our Senſes, whenever we ſtop, and feel a gentle Air fanning and overtaking us. But if we go along with it, we ſhall not perceive it at all; but if we ſtep forwards quick, inſtead of an Air that accompanies us, we ſhall find it contrary and blowing in our Faces. Thus when the Atmoſphere is quite at Reſt, and ſtagnating as it were, if we walk or ride, we then perceive a gentle Air as it were meeting us, and of juſt ſuch a Strength as anſwers our own Motion. And an Air of Wind ſeems to move with the ſame Motion or Velocity, as we ourſelves move the contrary Way.

We may make many uſeful Inferences from theſe Obſervations about the Velocity of the Winds. Particularly we may aſſign one Reaſon why the Mercury aſcends and deſcends ſo long before fair Weather or Rain follows.

But I ſhall omit ſuch Things as theſe, as being foreign from my Purpoſe. I ſhall only obſerve this as to Sounds, that when their Motion is ſwifter than the Wind, it appears that thoſe Parts of the Atmoſphere on which Sounds are impreſs'd, or by which they are carried, are not the ſame as thoſe of which Winds are compoſed, but ſome others more etherial or volatile, as far as may be conjectured. For the ſwifteſt Winds hardly fly above 60 Miles in an Hour, whereas Sounds can paſs above 700 Miles in the ſame Space of Time.

Now if it ſhould be objected, that Winds make Sounds ſwifter or ſlower, it might be anſwer'd, that this does not proceed from the proper Flux or Tendency of the windy Particles alone, but rather from the conjunct and conſpiring Motion of all the Particles of the Atmoſphere, as well the groſs as the ethereal. Which Direction of the Courſe or Motion, if it favours the Undulations of the Sounds, their Motions will be thence accelerated, but if it is contrary to them, they will be retarded, as is very probable.

Of the Velocity *of* Sounds.

13. Therefore I conclude very ſtrongly from what has been now ſaid, and many other Things before taken Notice of, that Sounds are propagated according to theſe Degrees of Velocity; that the Diſtance of a Mile, or 5280 *Engliſh* Feet, is deſcribed in the Space of 9¼ Half-ſeconds, or which is the ſame Thing, they deſcribe 571 Feet in one Semi-ſecond, or 1142 Feet in the Space of one Minute.

Now Sounds paſs over the aforeſaid Space if the Courſe of the Atmoſphere is oblique, and is their mean Progreſs or Motion. But if the Wind increaſes the Rapidity of the Sound, it is poſſible they may paſs over 600 Feet or more in the Space of a Half-ſecond. But on the contrary if it hinders, they may not paſs over above 560 Feet in the ſame Time.

Now the aforeſaid Obſervations and Experiments may not be a little ſerviceable

To a *Philoſopher*, for explaining the abſtruſe Phenomena of Sound.

To a *Mariner*, who may learn from hence, how far Ships are from him, which he ſees fluctuating or lying at Anchor before him, or how far he is from Land which he ſees at a Diſtance. Theſe Things may be known by the Diſcharge of Guns made on Purpoſe, or from a Signal given, and that very ſurely and exactly.

To a *Soldier*, to find at what Diſtance the Camp of the Enemy is from him, or a City beſieged. For the Elevation of great Guns upon Fortifications, for directing of Bombs, *&c.*

To a *Geographer*, for the eaſy and exact Menſuration of the Diſtances of Places. For any one in the Space of a few Hours may make a Map of a whole Country very exactly by this Means. For Guns diſcharged will ſhew the Diſtances, and any Mathematical Inſtrument for meaſuring Angles, or the common Inſtrument of Surveyors call'd *the Plain Table*, or only a Ruler provided with Sights, will ſhew the Situation of the ſeveral Places: From whence it will be no difficult Matter to delineate them.

Laſtly, this Method of Obſervation may be applied very conveniently to the Meaſuring of inacceſſible Places, eſpecially very wide Rivers, and ſuch Places whoſe Diſtances are otherwiſe very difficult to meaſure.

Of the Motion *of* Echo's.

To the *Meaſurer of Echo's*. Of this ludicrous and pleaſant Phenomenon of Sounds, the Echo, though many learned Men have formerly and lately made very anxious Enquiries, yet they are not well agreed about many Things concerning it. Particularly about the Space neceſſary for the Repetition of 1, 2, 3, or more Syllables, or which comes to the ſame, of the Space deſcribed by the Echo in a certain Space of Time. *Merſennus* allows ..... Paces to the Repeating of a Word of one Syllable: *Blancanus* 24 Paces, with whom Dr. *Plott* agrees. But *Kircher* affirms, that nothing certain can be determin'd about it, becauſe different Winds, and the different Intention and Remiſſion of the Force of the Sound, and many other Circumſtances, produce an immenſe Variety.

But it is not difficult to aſſign a Reaſon for all this Diſagreement. For it may ariſe from many Cauſes: From the Dullneſs or different Diſpoſition of our Senſes; From the various Audibility of the Sounds: From the grave or acute Tone of the Syllables themſelves, or their contracted or prolonged Pronunciation; or from any other Cauſe, that prolongs the Interval of Time. For I make no Doubt, for Example's Sake, but that if any Object that reflects Sound could return all the Syllables of this Verſe,

Vocalis Nympha, quæ nec reticere loquenti,

it could hardly return all the Syllables of the Verſe following, becauſe their Pronunciation muſt be ſomething longer, *Corpus adhuc Echo, non Vox erat, & tamen uſum.*

And much leſs could it repeat all the harſh and long Syllables of the following Verſe, tho' their Number is much fewer, *viz.*

Arx, tridens, roſtris, ſphynx, præſter, torrida, ſeps, ſtryx.

But we may conclude from the foregoing Obſervations about the Motion of Sound, that in the ſame Manner as Sounds, ſo Echo's deſcribe certain determinate Spaces in certain Times. This I have often been convinced of by Experience, that the Echo returns in twice the Time in which the Voice reach'd the reflecting Object. For Example, if the Obſtacle reflecting the Sound was diſtant a Furlong, then the Return of the Echo was made in the ſame Interval of Time, in which the primary Sound would have deſcribed two Furlongs, if it had not been interrupted.

And this in meaſuring the Diſtances of Places was often of great Uſe to me. For Example, as I ſtood upon the Bank of the *Thames*, over-againſt *Woolwich*, the Echo of a Monoſyllable was reverberated by the oppoſite Houſes in ſix Half-ſeconds of Time. Whence I collect, that the Breadth of the River *Thames* in that Place was 1712 *Engliſh* Feet from Bank to Bank, or above a Quarter of a Mile: For as 9,25 Semi-ſeconds is to 5280 the Feet in one Mile; ſo is 6 Semi-ſeconds to 3424,8 Feet. The Half of which is 1712,4 Feet.

Laſtly, by this Means the Height of Thunder-clouds, and the Diſtance of Thunder and Lightning itſelf, may eaſily be known.

Of the Nature *and* Properties *of* Sound, *by* G. Grandus, n. 319. p. 270.

XI. The moſt learned Archbiſhop of *Armagh* compares the Science of Hearing with that of Seeing, or with the Science of Viſion, and divides it into Direct, Reflected, and Refracted, in the ſame Manner as the other; ſo that he conſiders not only direct and reflected Sounds, as others had done before him, but alſo refracted Sounds. He obſerves, that as Viſion has been perfected in a great Meaſure by our Anceſtors, by excellent Optical, Catoptrical, and Dioptrical Inventions; ſo he doubts not but the Hearing may be greatly improved by Acouſtick, Catacouſtick, and Diacouſtick Inſtruments, or by Phonicks, Cataphonicks, and Diaphonicks, (for he denominates them both Ways) as well in reſpect of the Object as of the *Medium*, or of the Organ. He propoſes Problems thereto belonging, which are exhibited in this Diſcourſe, but not only without any Demonſtration, but alſo without Determination or Conſtruction. But there are many Differences, by which the Propagation of Light is diſtinguiſh'd from the Diffuſion of Sound. Among which this is a notable one, that Light is diſperſed always according to right Lines, whilſt Sound is ſcatter'd every Way according to Curves, or any crooked Paths, and becomes ſenſible, though the Obſtacle of any opague Body is interpoſed.

Vid. ſupr. V. I. C. V. S. XXII.

And thoſe very Things which the very learned Author treats of concerning the Diffuſion of Sound, plainly manifeſt its Difference from the Propagation of Light. For he teaches, that Sounds very eaſily run along Walls, or ſmooth Arches, which have an Elliptical or Cycloidal Flexure rather than a

Circular, and that with a kind and expeditious Courſe; and readily moves along the ſoft Superficies of Water, complying with the ſonorous Tremors with which the Air is ruffled. Now this I fear is not ſo generally obſerved in the Propagation of Light: For in the Ellipſis we have this only demonſtrated in Catoptricks, that the Rays of Light proceeding from one *Focus* D, Fig. 176. and impinging upon the Elliptical Curve ABC, being thence reflected will be collected in the other Focus E. But if the Rays proceed from any other Point G, except the Foci, they will no longer meet in the ſame Point, but will be ſo reflected as by their Contact to form the Cauſtick Curve *f* F *f*; ſo that being upon its Convexity, they can have only a reflected Ray or two, and not more, but lying in the Curve itſelf, they will coincide with thoſe that are neareſt. But ſuch as are within the Concavity of the ſame, will have no reflected Rays, nor can hope for any Advantage from them.

As to the Cycloid, the learned Mr. *John Bernoulli* has ſhewn, in the *Acts* Fig. 177. *of Leipſick* for 1697, that a Ray of Light, if it were to paſs through *Media*, whoſe Denſities varied in every Point according to a ſubduplicate Ratio of the Altitudes, would be ſo continually refracted, as that it would be bent into the Curve of a Cycloid. But I cannot perceive what the Figure of a Cycloid would contribute to the better Diffuſion of Light. For this Curve is without any Foci, ſo that it cannot recollect the Rays to a Point, but the reflected Rays will paſs from it into irregular Curves, unleſs when Rays PM, QN, parallel to the Axis KL fall upon the Cycloid EMKNH; for then the Cauſtick Line form'd by the Contact of the reflected Rays MR, NS, would be compoſed of the two Cycloids ERL, HSL, generated by a Circle of Half the Diameter, and would exhibit very denſe reflected Rays about L the Confine of each, at the Middle of the Baſe of the reflecting Cycloid. But as well in theſe as in other Cauſticks, reſulting from any Poſition of the luminous Point and the Rays, the ſame Obſervations would take Place, which we have already ſhew'd to belong to Cauſticks form'd by an Ellipſis.

I have nothing to add concerning the plain Superficies of Waters, ſince it appears, that the Rays of Light will paſs through it, either altogether refracted, or will be ſent back the contrary Way by Reflexion, juſt as by the Surface of a ſolid Chryſtal, nay ſomething more ſtrongly by this than by that; ſo far are they from creeping eaſily along its Side, that they may the more expeditiouſly be ſent directly forwards, and obtain that ready Progreſs, which the Author attributes to the Harmonic Tremors creeping along the ſoft Surface of the Waters, and by its waving Motion accommodating itſelf to their Flexure. Nay we may juſtly doubt, whether the moſt ſmooth Superficies of Specula, as well as of Light, would much conduce to the Reflexion of Sound, ſince the Echo itſelf ſeems to inhabit the very rough Receſſes of Caves, rather than poliſh'd Walls, and ſuch as are lined with a thin fine Mortar; ſince it often returns an Anſwer from uncultivated Vallies, from uneven Caverns, and from the Ruins of old Buildings.

Yet I would not be underſtood as deſigning to detract any Thing from the Credit, or the Praiſe due to what is advanced by the learned Author, who

I think is rather to be encouraged to the Publication anew of this Theory of Sounds, that we may know by what Law theſe ſonorous Tremors are propagated through the Air, Water, and all Kind of Bodies of any Denſity, both fluid and ſolid: And in what conſiſts that Congruity between Light and Sound, which as yet is unknown to us. Hence the Foundations of Acouſticks being confirm'd, this Science may hereafter be wonderfully improved, after the Diſcovery of proper Inſtruments for congregating, increaſing, promoting, multiplying, and diſtinguiſhing Sound. I ſhall endeavour in ſome Manner to explain his Acouſticon, or the Phonick Sphere propoſed by him, and that rather by divining than interpreting; firſt giving his own Words, that they may be compared with my Conjectures to be added afterwards, and that every one may be able to judge how exactly they anſwer.

I ſhall here add, ſays the Author, *a Semiplane of an Acouſtick or Phonical Sphere, as an Attempt to explicate the great Principle of this Science, which is, the Progreſſion of Sounds. You are to conceive this rude Semiplane as parallel to the Horizon, for if it be perpendicular thereunto, I ſuppoſe the Extremity will be no longer Circular, but Hyperbolical, and the lower Part of it ſuited to a great Circle of the Earth. So that the whole Phonical Sphere, if I may ſo call it, will be a ſolid Hyperbola, ſtanding upon a concave Spherical Baſe.* The Diagram Fig. 178. tranſmitted from *London* was after this Manner, but without any Notes or Explication by which it might be illuſtrated.

Therefore ſubſtituting this other Figure, I ſhall attempt to explain the Mind Fig. 179. of the Author. Let the Globe of the Earth be CGFE, and at the Point C of its Superficies let a Sound be excited. This will be propagated round about by the Earth itſelf, and alſo by the Air; ſo that at what Time it arrives at the great Circle of the Earth deſcribed with the Pole C, tho' perhaps inſenſibly, or at leaſt might arrive at it, if it were forcible enough, being diffuſed through the Air it would fill up a certain Space, according to the different Degrees of eaſy Paſſage, not extended altogether ſpherically, but unequally, and circumſcribed by the Perimeter of the Hyperbola GLAKE, about the Axis CAO, which is perpendicular to the ſonorous Body C: Or rather determin'd by the Superficies of an Hyperbolical Conoid, which is generated by the Rotation of the Hyperbola ALG about its Axis. Therefore the entire Phonical Sphere, through which the Sound is extended in a given Time, will be the ſolid Space comprehended by the Hyperbolical Conoid GAEB, which ſtands upon the great Circle of the Earth GBE, and is terminated below by the concave hemiſpherical Superficies GCEB. Which Space being cut any where by a Plain parallel to the Horizon will exhibit the Semicircle LIK, ſuch as the Author's Figure ſhews, which he calls a Semiplane, becauſe the View of his Diagram exhibits only one Half of it, the other Half remaining conceal'd beyond the vertical Hyperbola, which itſelf cuts the Phonick Sphere through the Axis into two equal Parts. But what is the Species of this Hyperbola, or by what Principles this Doctrine is ſupported, neither the Author himſelf ſhews, nor have I any Foundation to build Conjectures upon.

Therefore proceeding in an indirect Order of Inveſtigation, I ſhall firſt explain, through what Species of Lines the ſonorous Tremors muſt be propagated, that they may be expanded into ſuch an Hyperbola in a given Time; ſecondly, what we muſt ſuppoſe the Variation of Rarity to be at different Altitudes of the Air, that admitting the common Law of Refraction obſerved by the Rays of Light, ſo that it may bend the Directions of Sounds according to the Species of Lines ſo found; and thirdly, what muſt be the Law of Refraction on the other Hand, which the ſonorous Tremors obſerve in thoſe Curves, ſuppoſing the Variation of the Air's Denſity to be ſuch as moſt Philoſophers and Mathematicians allow, according to the reciprocal Ratio of the Weight of the incumbent Atmoſphere, preſſing the lower Parts downwards; which they contend to be confirm'd by Experiment.

For which let us conſider, that the ſonorous Body C communicates its Tremors every Way according to the Directions C*n*, C*m*, C*b*, or certainly Fig. 180. according to thoſe Lines by which the Impulſe was made, that by reſtoring itſelf it repel'd the Air, and urged it on by the frequent Oſcillations by which it is agitated, and is put into a tremulous Motion when diffuſed according to the ſame Directions. Therefore in a certain little Time let theſe Tremors be conceived to arrive at the Points *m*, *n*, *b*, whence purſuing their Way after another given Time they will be ſucceſſively propagated, the firſt to the Point N, the Second to M, and the Third to H. Again, after another given Time they will arrive together, the firſt at G, the other at L, the laſt at A. Therefore I ſhall now call the Lines C*n*NG, C*m*ML, C*b*HA, the ſonorous Rays being thoſe through which every Tremor is ſucceſſively diffuſed; but the Lines *n m b*, NMH, GLA, which the aforeſaid ſonorous Rays, and all other that are ſynchronous and intermediate to them, together approach to in any given Time, I ſhall call *ſonorous Waves*.

And indeed in a *Medium* which is every where quite uniform, the Cauſe ceaſing which compels the ſonorous Tremors to go out of their Direction, it is plain the ſonorous Rays muſt always proceed ſtrait on, or go directly the ſhorteſt Way from one Term to another, which will make the Waves to be perfectly circular, and concentrical to the ſonorous Body. For ſince they find no greater Difficulty to paſs here than elſewhere, they will be promoted at equal Diſtances in every given Time. Now every Ray will cut its Wave perpendicularly, and all the Waves will be concentrical and ſimilar, as is plain from the Elements.

But in a *Medium* of unequal Denſity, as in the Air ſurrounding the Earth, which according to its different Diſtance has a different Degree of Rarity, (for now we ſhall abſtract from its Viciſſitudes of Heat, Cold, Humidity, and Dryneſs, which cannot be reduced to any certain Rule) the Ray CHA alone paſſing perpendicularly through all the aerial Layers, or Superficies concentrical to the Earth, will continue direct and unrefracted; but others falling obliquely upon the ſame Superficies, will be refracted at every Point by a certain continual Flexure, and will be bent into the Curves C*m*ML, C*n*NG; and according to the different Facility of Paſſage will not proceed every where to the ſame Diſtance in the ſame Time. Wherefore the Points A, L, G, or H, M, N, which the Sound emitted through any Rays at the ſame Moment of Time, will be unequally diſtant from the ſonorous Body C, and thence the Lines A L G, H M N, *b m n*, will by no Means be Circles concentrical to the ſonorous Body, but Curves of another Kind, which however will be ſimilar to one another, and ſimilarly poſited. Wherefore in the Hypotheſis of our Author, who will have that extream Wave A L G to be Hyperbolical, which ſurrounds the ultimate Limits of the Terraqueous Globe; it muſt follow, that any other intermediate ones H M N, *b m n*, muſt be like Hyperbola's, and ſimilarly poſited to the different Vertices A, H, *b*, but deſcribed with the ſame Center, to the ſame Axis, and under like Figures of their Latera. For by whatever Method it may be ſhewn, that becauſe of the ſimultaneous Appulſe of the Sound to the Points A, L, G, through the ſynchronal Paſſages C H A, C M L, C N G, the Wave A L G will become a Curve of ſuch a Species, ſuppoſe Hyperbolical; the ſame will prove from the ſame Foundations, becauſe alſo of the ſimultaneous Appulſe of the Sound to the Points H, M, N, by the ſynchronous Lines C *b* H, C *m* M, C *n* N, the Wave H M N will paſs into a Curve of the ſame Species, which in this Caſe will be a ſimilar Hyperbola, and ſimilarly poſited, as appears of itſelf. Nor can there be any Doubt but that the ſonorous Rays C H A, C M L, C N G, muſt always cut thoſe ſimilar Waves A L G, H M N, *b m n*, perpendicularly or at right Angles, as happens in the circular Waves. And as the learned Mr. *Huygens*, in his *French* Treatiſe concerning Light, *p.* 44, has proved this in a like Subject concerning Lucid Waves, we need not ſpend any more Time in confirming this Obſervation here.

Therefore the Inveſtigation of the Paſſage according to which the Propagation of the ſonorous Rays are perform'd, in the Hypotheſis of our Author, is reduced to this purely Geometrical Problem; to find the Nature of thoſe Curves, which cut perpendicularly any ſimilar Hyperbola's which are deſcribed about the ſame Axis, and the ſame Center in a ſimilar Manner. Let A L G, Fig. 181. H M N, *b m n*, and innumerable others intermediate, be ſimilar Hyperbola's and ſimilarly poſited either above or below theſe, having the ſame common Center O, and deſcribed with the ſame Axis O A H, to which the other O S is conjugate. Through the Point C the Curve C *m* M L or C *n* N G is to be drawn, which may cut perpendicularly all the Hyperbola's propoſed. Thro' the given Point C, between the Aſymptotes O A, O S, let an Hyperbola C *m* M L of ſuch a Nature be deſcribed, that ſuppoſing the Ratio of the tranſverſe Diameter of the former Hyperbola's A L, H M, *&c.* to the *Latus Rectum* of the ſame to be equal to the Ratio of *t* to *r*; the Powers of the Ordinates L Q denominated by the Exponent *r* may be reciprocally proportional to the Powers of the Abſciſſes from the Center O Q, denominated by the Exponent *t*. That is, making $OQ = x$, and $QL = y$, it may be $y^r = \frac{1}{x^t}$. Or drawing any other Ordinate *m i*, M I; ſo that the Ratio of the

Diſtances from the Center OQ, OI, may be ſuch a Multiple of the Ratio of the Ordinates IM, QL, reciprocally, as the Fraction $\frac{r}{t}$ is a Multiple of Unity. I ſay, that this will ſatisfy the Demand. For drawing LP a Tangent to any Hyperbola AL in the Point where it is cut by the Curve CML, as alſo SLR a Tangent of the Hyperbola CML in the ſame Point; it appears from what we have ſhewn in the Demonſtration of *Huygens*'s Theorems, *c.* 7. *n.* 9. that it will be OQ to QR as the Exponent of the Power of the Diſtances OQ, to the Exponent of the Power of the Ordinates QL, that is, as t to r. But as t to r, or the *Latus tranſverſum* to the *rectum*, ſo is (by 37 *L. Conic.*) the Rectangle OQP to the Square of QL. Therefore it is as OQ to QR, or taking a common Altitude QP, as the Rectangle OQP to the Rectangle PQR, ſo is the Rectangle OQP to the Square of QL, which therefore will be equal to the Rectangle PQR. Therefore the Angle PLR will be a right one. And hence the Curve CML cuts the Hyperbola ALG perpendicularly in the Point L. And in the ſame Manner it will be proved to be perpendicular to the other Hyperbola's HMN, *hmn*, in the Points M*m*, in which it cuts them. *Q. E. D.*

Hence we may infer, firſt, that if the Hyperbola ALG, determining the Phonick Sphere of the Author, and the other like concentrick ones HMN, *hmn*, are equilateral; then becauſe of the Equality of the Sides t and r, the Hyperbola CML will be that of *Apollonius*, and alſo equilateral. For its Equation before exhibited will be changed into this $y = \frac{1}{x}$, where the Ratio of the Ordinates is ſimply reciprocal to the Ratio of the Diſtances from the Center. Therefore alſo the ſonorous Rays, as alſo the ſonorous Waves, according to this Hypotheſis would be Hyperbola's of the ſame Species, but only in a different Poſition. I remember that *Newton* ſhews in his *Opticks*, *l.* 3. *p.* 287. *Ob.* 10. that when Rays of Light received into a dark Room are made to paſs over the Edges of two Knives, they are alike bent into Hyperbolical Frindges, ſuch as CML; of which Phenomenon, if the phyſical Cauſe could be aſſign'd, the ſame perhaps might prevail with us to believe, that the Rays of Sound are alſo Hyperbolical, ſuch as the Syſtem of the Archbiſhop of *Armagh* ſeems to require.

Secondly, it is to be obſerved, that if many ſuch Curves were deſcribed, or Hyperbolical Rays *m*ML, *n*NG, *&c.* perpendicularly cutting the Hyperbolical Waves ALG, HMN, *&c.* they could not meet exactly in one Point C, though they might approach nearer and nearer towards C and might come to a Diſtance leſs than any aſſignable. Therefore thoſe Hyperbolical Rays muſt be conceived to proceed from a Corpuſcle C of ſome Extenſion, and not from a Mathematical Point, which is moſt agreeable to it. For Sound is produced by the Colliſion of Bodies, and cannot be generated

nerated by the Tremor of what is ſtrictly a Point, or one Form of Extenſion.

Nay, ſince all the Waves propagated from a ſonorous Body, as we have ſeen above, ought to be ſimilar Hyperbola's; it is proper we ſhould conceive the ſonorous Body C to be as it were a very ſmall Fibril vibrating very ſwiftly, whoſe leaſt and as it were initial Wave, being almoſt infinitely ſmall 2, 3, 4, is itſelf truly Hyperbolical, or rather the phyſical Apex of ſome Hyperbola. So that the vibrating Fibril of the ſonorous Body C, for Example, while it is ſtruck, being diſturbed from its direct Situation 2 C 4, by the Force of Percuſſion into the concave Situation 2 5 4, then being reſtored by the Force of its very vehement Elaſticity and alſo of its proper Tenſion, it ſwells into the convex Hyperbola 2 3 4, and again reduced by alternate Vibrations, and fluctuating on each Side expands its Tremors into Hyperbolical Waves always ſimilar to the initial ones 2 3 4, 2 5 4, upwards and downwards of their own Nature, in a *Medium* without Reſiſtance. But perhaps being hinder'd by the Obſtacle of the Earthly Globe C E, whoſe Center is T, it may propagate its Hyperbolical Waves only upwards, and deſcribe the Phonick Sphere imagin'd by our Author, interrupted and limited in its lower Part by the Terreſtrial Hemiſphere.

Now if the Doctrine of *P. Pardies* is true, which is propoſed Artic. 81. of his *Staticks*, that Strings ſtretch'd by the Force of their own Weight aſſume an Hyperbolical Figure, ſuch as 2 5 4, whoſe Center is the ſame as that of the Earth; every one may ſee this would be moſt congruous for confirming the Syſtem of our Author. Hence alſo a Reaſon would be ſupplied, why every Fibril of a ſonorous Body C, while it is agitated by harmonical Vibrations, would put on the Form of the Hyperbola 2 5 4, having its Center in the Center of the Earth T, and in like Manner would ariſe to another equal to it 2 3 4, and thence would diffuſe the Tremor through other and larger Hyperbola's, the Center of all which would be O, equally diſtant from the ſonorous Body C, as the ſonorous Body itſelf is diſtant from the Center of the Earth. Wherefore the Diſtance C O, equal to the Diameter of the Terraqueous Globe, would determine the Limit beyond which no ſonorous Wave would be propagated, and no Sound could be heard. And the Line O S, as being the Aſymptote of any of the Hyperbolical Rays, through which the Sound is convey'd, would be the Confine of that happy Region, in which Men might philoſophize in the utmoſt Tranquility, ſecure from all Noiſe of Earthly Affairs.

Now that no one may think this Speculation is to be deſpiſed on this Account, becauſe every Fibril of a ſonorous Body, as being very ſhort and very much diſtended, ſhould ſeem always to remain in a ſtrait Situation 2 C 4, nor can ever be bent into the concave or convex Hyperbola's 2 5 4, 2 3 4; it is to be conſider'd, that Hyperbola's are ſo much the more enlarged, and approach ſo much the nearer to a right Line, the longer their Axes become. Therefore becauſe of the vaſt Diſtance of the Centers T or O, like Lines which falling Bodies deſcribe, are eſteem'd as Parallels tho' directed to the

Center of the Earth, and the Arches of a horizontal Circle are not diſtinguiſhed from a right Line that is a Tangent; ſo thoſe initial Hyperbola's 254, 234, may be ſaid almoſt to coincide with the right Line 2C4. Whence the Curvature of the vibrating Fibrils in a ſonorous Body is not ſenſible, nor does the Species of the Hyperbolical Waves diſcover itſelf, till they are dilated into a larger Space G L A L G, and approach nearer to their Center.

Yet here it is to be obſerved, that it will follow from theſe Principles, the Sound will not paſs at the Sides beyond the Space comprehended by the extream Hyperbolical Rays 298*g*, 476*g*, which the right Lines T2, T4, would touch, drawn from the Center of the Earth through the Terms of the vibrating Fibril. And indeed the Tremors of that Fibril would not proceed according to any other Direction than by T 2, T 3, T 4, and other intermediate ones comprehended by the Angle 2T4, correſponding to the ſeveral Particles of the ſame Fibril. Therefore the Space without the ſaid Hyperbola's 298*g*, 476*g*, would remain without any harmonical Tremor, nor according to the Meaning of the Author could the Phonical Sphere be extended to the whole Hemiſphere of the Earth. Therefore no one Fibril of the ſonorous Body muſt ever tremble, but that at the ſame Time it muſt draw the Terms of the other Fibrils with which it is connected, and between which it is diſtended, and muſt likewiſe excite them to an harmonical Tremor. Theſe muſt bring others with which they are connected, and make them tremble likewiſe; juſt as a muſical String ſtretch'd on a wooden Inſtrument evidently communicates its Tremors to it. Hence harmonical Oſcillations are preſently transfuſed into other Bodies, with which they are mediately or immediately connected, tho' always more and more weakened, and at laſt becoming inſenſible are ſpread through the Superficies of the Earthly Hemiſphere, and creep on farther and farther. This the Ear itſelf can teſtify, if applied to the Earth, and may diſtinguiſh any great Noiſe, tho' raiſed afar off. Therefore alſo from other Places other ſonorous hyperbolical Rays emerge through the whole Hemiſphere of the Earth, by which the Phonick Sphere of the Archbiſhop of *Armagh* may be ſufficiently repleniſh'd.

I intend to be ſhorter in diſcuſſing the two remaining Problems which I have propoſed above. And yet I ſhall endeavour to ſolve the ſecond Queſtion after a more general Manner, that its Uſe may be the more extenſive. Let N*n*G be ſuppoſed to be any Ray, either lucid or ſonorous, changed into a Curve of any Kind, by a continual Refraction. 'Tis enquired after what Law the Denſity muſt be ſuppoſed to be varied, or the Rarity of the *Medium* at its different Altitudes; that admitting the Theory of Refraction, which ſuppoſes the Sine of Refraction to be always proportional to the Rarity of the refracting *Medium*, that Ray may become a Curve of ſuch a Nature? Let the Axis of the Curve N*n*G made by the refracted Ray, be the right Line CO, in which taking any Point C, with any Radius CL let the circular Quadrant LP*p* be deſcribed, and drawing any where the Tangent NR, *nr*, of the refracted Ray, from C let there be drawn a Ray parallel to the ſaid Tangent, meeting the Circle in P, and drawing PF parallel to the Axis, let it meet the Ordinate NQ perpendicular to the Axis in the Fig. 182.

Point F, I ſay that the Curve thence ariſing FfF by its Ordinates FQ, fq, will expreſs the Rarity of the *Medium* at its different Altitudes. For becauſe C P is parallel to R N, the Angle P C B will be equal to that Angle which the refracted Ray N n makes with the Perpendicular at the Point N. And therefore B P or F Q will always be the Sine of Refraction, the whole Sine being C P. Wherefore ſince the Law of Refraction is ſuppoſed to be ſuch, that the Sine of the ſame is proportional to the Rarity of the *Medium*, the ſame Line F Q will denote the Rarity of the *Medium* at the Altitude Q, or at the Point N of the ſame Altitude, through which the Ray paſſes. *Q. E. D.*

Now in our Propoſition, in which $QN = \frac{r}{x^{\frac{t}{r}}}$, becauſe of $y^r = \frac{1}{x^t}$, if FQ denoting the Rarity of the Air be called z, it will be $z = \frac{t}{\sqrt{x^{2r+2t} + tt}}$; or taking r and C P for Unity, 'tis $z = \frac{t}{\sqrt{x^{2+2t} + tt}}$. And in the Caſe in which the hyperbolical Wave is equilateral, and therefore the Ray alſo is a like equilateral Hyperbola, 'tis $y = \frac{l}{x}$, becauſe $t = 1$, and therefore it will be $z = \frac{1}{\sqrt{x^4 + 1}}$.

Now becauſe as well *Jacobus Hermannus* in the Acts of *Leipſick* 1706, as Dr. *D. Gregory* in his Aſtronomy, *l.* 5. prove the Curve which determines the Degrees of the Rarity of the Air to be the Logarithmic Curve, ſo that the Altitudes O Q, oq, or x, will be the Logarithms of the Numbers that expound the Rarities of the Air in the Points Q, q; it is plain that the Curvature of the continually refracted Rays N n, N G, proceeds in ſuch a Manner, that the Sines of the Complement of Incidence and of Refraction being raiſed to the Power $\frac{r}{r+t}$, ſhall have a Ratio compounded of the Ratio of the Right Sines raiſed to a like Power, and of the Ratio of the Logarithms of the Rarities.

But tho' I might grant that the ordinary Law of the Refraction of Light gives the Sines of Incidence and Refraction proportional to the Rarities of the *Medium*; yet I muſt not diſſemble, that perhaps this may not be very exact. For the Ratio of the Sines in the Refraction out of Air into Glaſs is about ſeſquialter, yet Air is above a thouſand Times rarer than Glaſs. But when Geometricians perceived, that the Sine of Refraction in the Paſſage into another *Medium* became greater, according to the greater Facility with which Light could penetrate it in the common Hypotheſis, or according to the greater Difficulty in the Opinion of *Carteſius*, who ſuppoſes on the contrary, that Light is more refracted, becauſe of the greater Difficulty in a rarer *Medium* than in a denſer, as heavy Bodies becauſe of a greater Difficulty in penetrating denſer Bodies, in theſe are more refracted by rebounding from the Perpendicular;

cular; and that both Laws agree in this, that according to the greater Rarity of the *Medium* there would be a greater Refraction. Hence it has obtain'd that the Sines are ſaid to be proportional not to the Facility or Difficulty of the Paſſage, either of which by ſome is call'd in Queſtion, but to the Rarity of the *Medium* in which all agree, tho' the true Proportion does not altogether anſwer to it in the ſame Geometrical Ratio. Therefore where-ever Mention is made of Rarity, perhaps we ſhould ſubſtitute Facility of Paſſage in the common Hypotheſis, or Difficulty in that of *Carteſius*, except where we ſay, that the Rarity ariſing from the Weight of the incumbent Atmoſphere correſponds to the Altitudes, as Numbers correſpond to their Logarithms. For this is moſt exactly agreeable to Truth.

A Paper omitted.

XII. Some Theorems concerning the infinite Diviſibility of Matter, which demonſtrate its great Rarity, and the Tenuity of its Compoſition, by Means of which many Difficulties in Phyſicks are removed. By Dr. *John Keill.* n. 339. p. 82.

CHAP. V.

Hydroſtatics. Hydraulics.

I. THE following Experiment ſeems to be of Uſe in diſcovering the Proportions of the Attractions of Fluids; I ſhall give what Account I can of it, though I have not here Conveniencies to make it in ſo ſucceſsful a Manner as I could wiſh.

Aſcent *of* Water *between two* Glaſs-Planes, *by Dr.* B. Taylor, n. 336. p. 538. *June* 25. 1712.

I faſtened two Pieces of Glaſs together, as flat as I could get; ſo that they were inclined in an Angle of about two Degrees and a Half, then I ſet them in Water with the contiguous Edges perpendicular. The upper Part of the Water, by riſing between them, made this *Hyperbola*, *Fig.* 183. which is as I copied it from the Glaſs.

Fig. 183.

I have examin'd it as well as I can, and it ſeems to approach very near to the common *Hyperbola*. But my Apparatus was not nice enough to diſcover this exactly.

The perpendicular *Aſymptote* was exactly determin'd by the Edge of the Glaſs; but the *Horizontal* one I could not ſo well diſcover.

II. Some Days ago a Method, propoſed to me by an ingenious Friend, for making a perpetual Motion, which ſeem'd plauſible, and eaſily demonſtrable from an Obſervation of the late Mr. *Hawksbee*, ſaid to be grounded upon Experiment, was tried; which (though not ſucceeding) has given Occaſion not only to rectify ſome Miſtakes, into which we had been led by the late Mr. *Hawksbee*,

The Cauſe *of the* Aſcent *and* Suſpenſion *of* Water *in* Capillary Tubes, *by Dr.* J. Jurin, n. 365. p. 739.

Hawksbee, but likewiſe to detect the real Principle by which Water is raiſed and ſuſpended in capillary Tubes above the Level.

Fig. 184. *My Friend's Propoſal was as follows.*] Let *A B C* be a capillary Siphon, compoſed of two Legs *A B*, *B C*, unequal both in Length and Diameter; whoſe longer and narrower Leg *A B* having its Orifice *A* immerſt in Water, the Water will riſe above the Level, till it fills the whole Tube *A B*, and will then continue ſuſpended. If the wider and ſhorter Leg *B C* be in like Manner immerſt, the Water will only riſe to ſome Height, as *F C*, leſs than the entire Height of the Tube *B C*.

This Siphon being fill'd with Water, and the Orifice *A* ſunk below the Surface of the Water *D E*, my Friend reaſons thus:

Since the two Colums of Water *A B* and *F C*, by the Suppoſition, will be ſuſpended by ſome Power acting within the Tubes they are contain'd in, they cannot determine the Water to move one Way or the other. But the Column *B F* having nothing to ſupport it, muſt deſcend, and cauſe the Water to run out at *C*. Then the Preſſure of the Atmoſphere driving the Water upward through the Orifice *A* to ſupply the Vacuity, which would otherwiſe be left in the upper Part of the Tube *B C*, this muſt neceſſarily produce a perpetual Motion, ſince the Water runs into the ſame Veſſel, out of which it riſes. But the Fallacy of this Reaſoning appears upon making the Experiments.

Exp. 1. For the Water, inſtead of running out at the Orifice *C*, riſes upwards towards *F*, and running all out of the Leg *B C*, remains ſuſpended in the other Leg, to the Height *A B*.

Exp. 2. The ſame Thing ſucceeds upon taking the Siphon out of the Water, into which its lower Orifice *A* had been immerſt, the Water then falling in Drops out of the Orifice *A*, and ſtanding at laſt at the Height *A B*. But in making theſe two Experiments, it is neceſſary that *A G*, the Difference of the Legs, exceed *F C*, otherwiſe the Water will not run either Way.

Exp. 3. Upon inverting the Siphon full of Water, it continues without Motion either Way.

The Reaſon of all which will plainly appear, when we come to diſcover the Principle by which the Water is ſuſpended in capillary Tubes.

Mr. *Hawksbee*'s Obſervation is as follows.

Fig. 185. Let *A B F C* be a capillary Siphon, into which the Water will riſe above the Level, to the Height *C F*, and let *B A* be the Depth of the Orifice of its longer Leg below the Surface of the Water *D E*. Then the Siphon being fill'd with Water, if *B A* be not greater than *C F*, the Water will not run out at *A*, but will remain ſuſpended.

This ſeems indeed very plauſible at firſt Sight. For ſince the Column of Water *F C* will be ſuſpended by ſome Power within the Tube, why ſhould not the Column *B A* being equal to, or leſs than the former, continue ſuſpended by the ſame Power?

Exp. 4. In fact, if the Orifice *C* be lifted up out of the Water *D E*, the Water in the Tube will continue ſuſpended, unleſs *B A* exceed *F C.*

Exp. 5. But when *C* is never ſo little immers'd in the Water, immediately the Water in the Tube runs out in Drops at the Orifice *A*, tho' the Length *A B* be conſiderably leſs than the Height *C F.*

Mr. *Hawkſbee*, in his Book of Experiments, has advanced another Obſervation, namely, that the ſhorter Leg of a Capillary Siphon, as *A B F C*, muſt be immers'd in the Water to the Depth *F C*, which is equal to the Height of the Column, that would be ſuſpended in it, before the Water will run out at the longer Leg.

Exp. 6. From what Miſtake this has proceeded, I cannot imagine; for the Water runs out at the longer Leg, as ſoon as the Orifice of the ſhorter Leg comes to touch the Surface of the ſtagnant Water, without being at all immers'd therein.

I proceed now to enquire into the Cauſe of the Aſcent and Suſpenſion of Water in capillary Tubes.

That this Phænomenon is no Way owing to the Preſſure of the Atmoſphere, has been, I think, ſufficiently prov'd by Mr. *Hawkſbee*'s Experiments.

And that the Cauſe aſſign'd by the ſame Perſon, namely, the Attraction of the concave Surface, in which the ſuſpended Liquor is contain'd, is likewiſe inſufficient for producing this Effect, I thus demonſtrate.

Since in every capillary Tube the Height, to which the Water will ſpontaneouſly aſcend, is reciprocally as the Diameter of the Tube, it follows, that the Surface containing the ſuſpended Water in every Tube is always a given Quantity: but the Column of Water ſuſpended is, as the Diameter of the Tube. Therefore, if the Attraction of the containing Surface be the Cauſe of the Water's Suſpenſion; it will follow, that equal Cauſes produce unequal Effects, which is abſurd.

To this it may perhaps be objected, that, in two Tubes of unequal Diameters, the Circumſtances are different, and therefore the two Cauſes, tho' they be equal in themſelves, may produce Effects that are unequal. For the leſſer Tube has not only a greater Curvature, but thoſe Parts of the Water, which lie in the middle of the Tube, are nearer to the attracting Surface, than in the wider. But from this, if any thing follows, it muſt be, that the narrower Tube will ſuſpend the greater Quantity of Water, which is contrary to Experiment. For the Columns ſuſpended are as the Diameters of the Tubes.

But as Experiments are generally more ſatisfactory in Things of this Nature, than Mathematical Reaſonings, it may not be amiſs to make uſe of the following, which appear to me to contain an *Experimentum Crucis.*

The Tube *C D* is compoſed of two Parts, in the wider of which the Water will riſe ſpontaneouſly to the Height *B F*, but the narrower Part, if it were of a ſufficient Length, would raiſe the Water to a Height equal to *C D.* Fig. 186.

Exp. 7. This Tube being fill'd with Water, and the wider End *C* immers'd in the ſtagnant Water *A B*, the whole continues ſuſpended.

Fig. 187. *Exp.* 8. The narrower End being immers'd, the Water immediately ſubſides, and ſtands at laſt at the Height *D G* equal to *B F*.

From which it is manifeſt, that the Suſpenſion of the Water in the former of theſe Experiments is not owing to the Attraction of the containing Surface: ſince, if that were true, this Surface being the ſame, when the Tube is inverted, would ſuſpend the Water at the ſame Height.

Having ſhewn the Inſufficiency of this Hypotheſis, I come now to the real Cauſe of that Phænomenon, which is the Attraction of the Periphery, or Section of the Surface of the Tube, to which the upper Surface of the Water is contiguous and coheres.

For this is the only Part of the Tube, from which the Water muſt recede upon its ſubſiding, and conſequently the only one, which by the Force of its Coheſion or Attraction, oppoſes the Deſcent of the Water.

This likewiſe is a Cauſe proportionable to the Effect which it produces; ſince that Periphery, and the Column ſuſpended, are both in the ſame Proportion as the Diameter of the Tube.

Tho' from either of theſe Particulars it were eaſy to draw a juſt Demonſtration, yet to put the Matter out of all Doubt, it may be proper to confirm this Aſſertion, as we have done the former, by actual Experiment.

Fig. 188. Let therefore *E D C* be a Tube, like that made uſe of in the 7th and 8th Experiments, except that the narrower Part is of a greater Length; and let *A F* and *B G* be the Heights, to which the Water would ſpontaneouſly riſe in the two Tubes *E D* and *D C*.

Exp. 9. If this Tube have its wider Orifice *C* immers'd into the Water *A B*, and be fill'd to any Height leſs than the Length of the wider Part, the Water will immediately ſubſide to a Level with the Point *G*; but if the Surface of the contain'd Water enter never ſo little within the ſmaller Tube *E D*, the whole Column *D C* will be ſuſpended, provided the Length of that Column do not exceed the Height *A F*.

In this Experiment it is plain, that there is nothing to ſuſtain the Water at ſo great a Height, except the Contact of the Periphery of the leſſer Tube, to which the upper Surface of the Water is contiguous. For the Tube *D C*, by the Suppoſition, is not able to ſupport the Water at a greater Height than *B G*.

Fig. 189. *Exp.* 10. When the ſame Tube is inverted, and the Water is rais'd into the lower Extremity of the wider Tube *C D*, it immediately ſinks, if the Length of the ſuſpended Column *D H* be greater than *G B*; whereas in the Tube *D E* it would be ſuſpended to the Height *A F*. From which it manifeſtly appears, that the Suſpenſion of the Column *D H* does not depend upon the Attraction of the Tube [illegible] but upon the Periphery of the wider Tube, with which its upper S[illegible]face is in contact.

For the ſake of thoſe who are pleas'd with ſeeing the ſame Thing ſucceed in different Manners, we ſubjoin the two following Experiments, which are in Subſtance the ſame with the 9th and 10th.

A B C is a Siphon, in whoſe narrower and ſhorter Leg *A B*, if it were of a ſufficient Length, might be ſuſpended a Column of Water of the Height *E F*; but the longer and wider Leg *B C* will ſuſpend no more than a Column of the Length *G H*. Fig. 190.

Exp. 11. This Siphon being fill'd with Water, and held in the ſame Poſition as in the Figure, the Water will not run out at *C* the Orifice of the longer Leg, unleſs *D C*, the Difference of the Legs *A B* and *B C*, exceed the Length *E F*.

Exp. 12. If the narrower Leg *B C* be longer than *A B*, the Water will run out at *C*, if *D C*, the Difference of the Legs, exceed *E F*; otherwiſe it will remain ſuſpended. Fig. 191.

In theſe two Experiments it is plain, that the Columns *D C* are ſuſpended by the Attraction of the Peripheries at *A*, ſince their Lengths are equal to *E F*, or to the Length of the Column, which by the Suppoſition thoſe Peripheries are able to ſupport; whereas the Tubes *B C* will ſuſtain Columns, whoſe Lengths are equal to *G H*.

Though theſe Experiments ſeem to be concluſive, yet it may not be improper to prevent an Objection, which naturally preſents itſelf, and which at firſt View may be thought ſufficient to overturn our Theory.

For ſince a Periphery of the Tube *E D* is able to ſuſtain no more than a Column of the Length *A F*, contain'd in the ſame Tube, how comes it to ſuſtain a Column of the ſame Length in the wider Tube *D C*, which is as much greater than the former, as the Section of the wider Tube exceeds that of the narrower? Fig. 188.

Again, if a Periphery of the wider Tube *D C* be able to ſuſtain a Column of Water in the ſame Tube, of the Length *B G*; why will it ſupport no more than a Column of the ſame Length in the narrower Tube *E D*? Fig. 189.

Which Queries may likewiſe be made with regard to the 11th and 12th Experiments.

The Anſwer is eaſy; for the Moments of thoſe two Columns of Water are preciſely the ſame, as if the ſuſtaining Tubes *E D* and *C D* were continued down to the Surface of the ſtagnant Water *A B*; ſince the Velocities of the Water, where thoſe Columns grow wider, or narrower, are to the Velocities at the attracting Peripheries, reciprocally as the different Sections of the Columns.

Exp. 13. From which Conſideration ariſes this remarkable Paradox, That a Veſſel being given of whatſoever Form, as *A B C*, and containing any aſſignable Quantity of Water, how great ſoever; that whole Quantity of Water may be ſuſpended above the Level, if the upper Part of the Veſſel *C* be drawn out into a capillary Tube of a ſufficient Fineneſs. Fig. 192.

But whether this Experiment will ſucceed, when the Height of the Veſſel is greater than that, to which Water will be rais'd by the Preſſure of the Atmoſphere, and how far it will be alter'd by a *Vacuum*, I ſhall give an Account ſome other time.

Having diſcover'd the Cauſe of the Suſpenſion of Water in capillary Tubes, it will not be difficult to account for the ſeemingly ſpontaneous Aſcent of it; For ſince the Water that enters a capillary Tube, as ſoon as its Orifice is dipt therein, has its Gravity taken off by the Attraction of the Periphery, with which its upper Surface is in contact, it muſt neceſſarily riſe higher, partly by the Preſſure of the ſtagnant Water, and partly by the Attraction of the Periphery immediately above that, which is already contiguous to it.

The Action *of* Glaſs Tubes *upon* Water *and* Quickſilver, *by the* ſame. n. 363. p. 1083.

III. In a former Diſcourſe, I maintain'd, that the Suſpenſion of Water in a capillary Tube was owing to the Attraction of a ſmall annular ſurface on the inſide of the Tube, which touch'd the upper Part of the Water. Among the ſeveral Experiments made uſe of to prove this Aſſertion, was that of a Glaſs Funnel of ſeveral Inches Diameter, having its ſmall End drawn out into a very fine Tube, which Funnel being inverted and fill'd with Water, the whole Quantity of Water therein contain'd was ſuſtain'd above the Level by the Attraction of that narrow *Annulus* of Glaſs, with which the upper Surface of the Water was in contact.

Soon after that Diſcourſe was printed, came out a Book publiſh'd by a Learned and Ingenious Member of this Society, in which that Experiment was accounted for in the following Manner.

Fig. 193. *If there be a Funnel, as A B C, full of Water, and whoſe wide End ſtands in a Veſſel of Water as B C; and the Top of the Funnel A ends in a Capillary Tube open at A, the whole Water will be ſuſtain'd; the Pillar A a by the Attraction of the Circle of Glaſs within the Tube immediately above it; and all the reſt of the Pillars of Water, as F f, D d, E e, G g, &c. in ſome meaſure by the Attraction of the Parts of the Glaſs above them, as F, D, E, G: And that the ſmall Pillars or Threads of Water, D d, and E e, do not ſlide down to F f, and G g, and ſo go quite down, ſeems to be owing to their Coheſion with the Pillar A a, which is ſuſtain'd by the Capillary Tube A: For if you break off the ſaid Tube at D E, the whole Water will preſently ſink down.*

As this Solution was different from what I had before given, and the Reputation of that Gentleman was ſufficient to give Weight to any of his Opinions; I thought myſelf under an Obligation to examine his Account of the Experiment, in order either to demonſtrate its Inſufficiency, or to retract my own Solution. Accordingly at the next Meeting of the Society, I produced the following Experiment.

Fig. 194. The Funnel *A F G B C*, whoſe lower Part *B C F G*, was cylindrical to a conſiderable Height, and whoſe Top was drawn out into a fine Tube at *A*, being fill'd with Water to the Height *B F*, ſo that the Surface of the Water *F G*, did not reach to the arched Part of the Funnel; I touch'd the End *A* with a wetted Finger, whereby a ſmall Quantity

of Water being inſinuated into the Capillary Tube at *A*, the Water contained in the Funnel was ſuſpended above the Level of the Water in the Ciſtern *D E*, as in the former Experiment.

In this Experiment it is manifeſt, that the little Columns, into which we may ſuppoſe the Cylinder of Water *F G B C*, to be divided, are no way ſuſtain'd by the Attraction of the arched Part of the Glaſs above them, ſince they have no Contact with it. Nor is there any ſuch middle Pillar of Water, which, by its Contact with the Tube at Top, is both ſuſtain'd itſelf, and helps to ſupport the Pillars about it; Upon the Suppoſition of which two Particulars, that Gentleman's Solution was founded.

This Experiment may be thus accounted for: The Cylinder of Water *F G B C*, by its Weight balances a Part of the Preſſure of the Atmoſphere, which is incumbent on the Water in the Ciſtern, and endeavours to force that Cylinder upwards. The reſt of that Preſſure is balanced by the Spring of the Air *A F G*, which is included between the Cylinder of Water *F G B C*, and the little Column of Water in the Capillary *A*. But as this Air by its Spring preſſes equally every way, it muſt balance as much of the Preſſure of the Atmoſphere upon the little Column of Water at *A*, as it does of that upon the Water in the Ciſtern. The Remainder of the Preſſure of the Atmoſphere upon the Column of Water at *A*, is ſuſtain'd by the Force, with which that Column adheres to the Capillary Tube, which therefore does exactly balance the Weight of the Cylinder of Water *F G B C*, and is the real, though not the immediate, Cauſe of its Suſpenſion.

The Experiment ſucceeds in the ſame Manner, when a Column of Quickſilver is raiſed into the Funnel, inſtead of the Column of Water *F G B C*, the Top of the Tube being touch'd with a wet Finger as before. But then the Height of the Quickſilver in the Funnel muſt be as much leſs than that of the Water, as its ſpecifick Gravity is greater.

I proceed now, according to Promiſe, to examine whether the Experiments therein contain'd, would ſucceed *in Vacuo*; and whether Water could be ſuſpended in a wide Tube by means of a Capillary at Top, at a greater Height than what it can be rais'd to by the Preſſure of the Atmoſphere.

In order to this, I boil'd ſome Water, and afterwards purged it of its Air, by means of the Air-pump; which being done, thoſe Experiments all ſucceeded in the exhauſted Receiver, in the ſame Manner as in the open Air.

The 13th Experiment in particular, was made with a Tube of about 35 Inches in Length, and a Quarter of an Inch Diameter, the Top of it being drawn out into a fine Capillary; which being fill'd with Water purged of its Air, as before-mention'd, the whole Quantity continued ſuſpended in the exhauſted Receiver.

This plainly ſhews that the Succeſs of that Experiment does not depend upon the Preſſure of the Air, ſince the ſmall Quantity of Air left in the Receiver, was by no Means capable of ſuſtaining the Water at ſo great a Height, and conſequently that the Height at which Water may be ſuſpended in this Manner, is not limited by that Preſſure.

But here I muſt not omit taking Notice of a conſiderable Difficulty, which preſents itſelf to thoſe who attentively conſider this Experiment. In order to make which the better appear, it will be proper to obſerve, what happens, when a ſimple Capillary Tube is fill'd with Water purged of Air, and incloſ'd in the exhauſted Receiver.

Fig. 195. In this Caſe, the whole Column of Water contained in the Tube *A C B*, is ſuſpended by the Attraction of the *Annulus* at the Top of the Tube *A*: And though that *Annulus* does not immediately act upon any Part of the Water, except what is either contiguous to it, or ſo near as to be within the Sphere of its Attraction, which extends but to a very ſmall Diſtance; yet it is impoſſible that any other Part of the Water, as for Inſtance, that at *C*, ſhould part from the Water above it, and ſink down; becauſe its Deſcent is oppos'd by the Attraction of the contiguous *Annulus* at *C*. For this being equal to the upper *Annulus* at *A*, is capable of ſuſtaining a Column of Water of the Length *A B*, and conſequently is more than ſufficient for ſupporting the Column of Water below it, *C B*, From which it is plain, that no Part of the Water contain'd in the Tube can poſſibly deſcend, unleſs the upper Part, aſſiſted by the Weight of the Water below it, be ſufficient to overcome the Attraction of the *Annulus* of Glaſs at *A*.

Fig. 196. But in ſuch a compound Tube, as that made uſe of in our Experiment, *A C B*, the Caſe is very different, and it does not eaſily appear, why in a *Vacuum* any Part of the Water in the wider Part of the Tube, as for Example at *C*, ſhould not leave that which is above it, and deſcend, ſince the *Annulus* at *C* is by much too wide to ſuſtain a Column of Water of ſo great a Length as *C B*.

The beſt Anſwer I can give to this Difficulty, is, that the Coheſion between the Water contained in the Capillary and that below it, is ſufficient to balance the Weight of the Column ſuſpended. But how far this Coheſion may depend upon the Preſſure of a Medium ſubtile enough to penetrate the Receiver, is worthy of Conſideration. For though ſuch a Medium will pervade the Pores of the Water, as well as thoſe of the Glaſs, yet it will act with its intire Preſſure upon all the ſolid Particles, if I may ſo call them, of the Surface of the Water in the Ciſtern; whereas ſo many of the ſolid Particles of the Water in the Tube, which happen to lie directly under the ſolid Particles of the Water above them, will thereby be ſecured from this Preſſure; and conſequently there will be a leſs Preſſure of this Medium upon any Surface of the Water in the Tube below the Capillary, than upon an equal Surface of the Water in the Ciſtern. So that the Column of Water ſuſpended in the Tube may be ſuſtain'd by the Difference between thoſe two Preſſures. This Explication ſeems to be favoured by the following Experiments, which may all be accounted for in the ſame Manner, though I ſhall anon mention another Cauſe, which contributes to the Succeſs of the firſt and ſecond.

The firſt I ſhall mention is the famous Experiment of the Suſpenſion of Mercury purged of Air, to the Height of 70 or 75 Inches in the *Torricellian-Tube*, in the open Air. To which we may add the ſuſtaining of Mercury, likewiſe purged of Air, within the exhauſted Receiver, as related by the learned Monſ. *Papin* in his *Continuation du Digeſteur*. I forbear to mention the Suſpenſion of Water purged of Air in the *Vacuum*, which he deſcribes in the ſame Book; becauſe there is little Difference between that Experiment and our own above-mentioned; the very Top of the arched Part of his Tube, which Top we may ſuppoſe as ſmall as we pleaſe, ſupplying the Place of the fine Capillary at the Top of our Tube. But we muſt not omit the Experiments made by the famous Monſ. *Huygens* *, of the cohering of poliſhed Plates, with a conſiderable Force in the exhauſted Receiver; as likewiſe of the running of Water and Mercury, when purged of Air, thro' a Siphon of unequal Legs in the *Vacuum*: All which he accounts for from the ſame Principle, and much in the ſame Manner, as we have uſed for explaining the Experiment above.

* Vid. ſupra V. II. p. 24.

As to the Exiſtence of ſuch a Medium, I ſhall content myſelf to refer to what has been ſaid by Sir *Iſaac Newton* in the Queries at the latter End of the laſt Edition of his *Opticks*: And as I have lately produced ſome Experiments upon Quickſilver, which were exactly the Reverſe of thoſe made by Dr. *Taylor*, the late Mr. *Hawkſbee* and my ſelf upon Water; by which I am now enabled to throw this whole Affair into a little Syſtem by itſelf, I ſhall lay it down in the following Propoſitions, the Proof of which is contained in the Experiments annexed.

Prop. 1. *The Particles of Water attract one another.*

This, I think, is now univerſally acknowledged, and therefore needs no Demonſtration; the Sphericity of the Drops of Rain, and the running of two Drops of Water into one another upon their Contact, manifeſtly proving it.

Prop. 2. *The Particles of Quickſilver attract one another.*

This is likewiſe manifeſt from the Spherical Figure, into which a Drop of Mercury forms itſelf upon a Table; and from two of them immediately running together, as ſoon as they come to touch.

Prop. 3. *Water is attracted by Glaſs.*

This plainly appears from all the Experiments that we have ſhewn upon this Subject.

Prop. 4. *Quickſilver is attracted by Glaſs.*

Experiment 1. If a ſmall Globule of Quickſilver be laid upon a clean Paper, and be touched with a Piece of clean Glaſs; upon drawing the Glaſs gently away, the Quickſilver will adhere to it, and be drawn away with it. And if the Glaſs be lifted up from the Paper, the Quickſilver

ſilver will be taken up by it, in the ſame Manner as a Piece of Iron is drawn up by the Loadſtone, and will ſtick to the Glaſs by a plain Surface of a conſiderable Breadth, in Proportion to the Bulk of the Drop, as manifeſtly appears by an ordinary Microſcope. Then if the Glaſs be held a little obliquely, the Drop of Mercury will roll ſlowly upon its Axis along the under ſide of the Glaſs, till it comes to the End, where it will be ſuſpended as before.

Exp. 2. If a pretty large Drop of Mercury be laid upon a Paper, and two Pieces of Glaſs be made to touch it, one on each ſide; upon drawing the Glaſſes gently from each other, the Drop of Mercury will adhere to them both, and will be viſibly drawn out from a globular to an oval Shape; the longer Axis paſſing from the middle of thoſe Surfaces, in which the Drop touches the Glaſſes.

Prop. 5. *The Particles of Water are more ſtrongly attracted by Glaſs, than by one another.*

This manifeſtly appears from the riſing of Water in ſmall Tubes above the Level. For when the Water begins to riſe into a Capillary Tube, all the Particles of Water, which touch the ſmall *Annulus* at the Bottom of the Tube, muſt have quitted the Contact of the other Water, and have riſen contrary to their Gravity, to come into Contact with the Glaſs. After the ſame Manner the other Experiments of Dr. *Taylor*, Mr. *Hawkſbee* and myſelf, upon this Subject, are eaſily explicable. For upon a careful Examination, it will be found in them all, that ſome Parts of the Water quit the Contact of the other Water, and join themſelves to the Glaſs.

Prop. 6. *The Particles of Quickſilver are more ſtrongly attracted by one another, than by Glaſs.*

Fig. 197. *Exp.* 1. If a ſmall Tube as A B, open at both Ends, be dipt into a Glaſs Veſſel fill'd with Mercury, and be held cloſe to the ſide of the Veſſel, that the riſe of the Mercury within it may appear; the Mercury will partly enter into the Tube, but will ſtand within it at ſome Depth, as C E, below the Surface of the Quickſilver in the Veſſel, C D; and this Depth will always be reciprocally as the Diameter of the Tube.

In this Experiment a Column of Quickſilver of the height C E endeavours to force the Mercury higher into the Tube; and as Glaſs has been already prov'd to attract Quickſilver, the Attraction of the annular Surface on the Inſide of the Tube, which is contiguous to the upper Part of the Mercury, will likewiſe conſpire to farther its Aſcent. What oppoſes the Aſcent of the Quickſilver, is the Power by which that Part of it, which endeavours to riſe into the Glaſs, is drawn back by the Attraction of the other Mercury, with which it is in Contact laterally, and this does not only balance the Attraction of the Glaſs, but likewiſe the Weight of the Column of Mercury C E, and conſequently this Attraction is conſiderably ſtronger than the Attraction of the Glaſs.

The Cauſe therefore that ſuſpends the Weight of the Column of Mercury C E, being the Difference between the Attraction of the annular Surface of the Tube at E, and that of an equal Surface of the Quickſilver in the Ciſtern, from which the Mercury, that endeavours to riſe into the Tube, muſt recede, in order to unite itſelf to ſuch an Annulus of the Glaſs, will always be proportional to that annular Surface, or to the Diameter of the Tube. And ſince the Column ſuſtained muſt be proportional to the Cauſe that ſuſpends it, that Column muſt likewiſe be as the Diameter of the Tube. But the Column ſuſpended, is as the Square of the Diameter of the Tube, and the height C E conjointly; from which it follows, that the height C E muſt be as the Diameter of the Tube reciprocally, as it is found to be by Experiment.

The Experiment of the Aſcent of Water above the Level in a Capillary Tube, is juſt the Reverſe of this.

Exp. 2. Quickſilver being poured into the inverted Siphon A C B, one of whoſe Legs A C is narrower than the other C B; the height C E, at which the Mercury ſtands in the wider Leg C B, is greater than the height C D, at which it ſtands in the narrower Leg CA. Fig. 198.

On the contrary, Water ſtands higher in the narrower Leg, than in the wider.

Exp. 3. ABCD repreſents a rectangular Plane of Glaſs, which makes one ſide of a wooden Box. On the Inſide of this is another Glaſs Plane of the ſame Size, which at the End AC is preſs'd cloſe to the former, and opens to a ſmall Angle at the oppoſite End B D. When Mercury is poured into this Box to any height as C E, it inſinuates itſelf, between the two Glaſs Planes, and riſing to different heights between the Glaſſes, where the opening is greater or leſs, it forms the common Hyperbola C G F; one of whoſe Aſymptotes E F is the Line on which the Surface of the Mercury in the Box touches the inner Glaſs; the other is the Line AC, in which the Planes are joined. This Hyperbola being carefully examined by Mr. *Hawkſbee* and my ſelf, the Rectangle E H G, whereſoever taken, proved always equal to itſelf, to as great an Accuracy as could be expected, when the Planes were opened to any conſiderable Angle: But when the opening was very ſmall, the Inequalities of the Planes, though the beſt I could procure, bearing a greater Proportion than before to the Diſtance between them, occaſioned a ſenſible Variation. Which, by the Way, I take to be the Reaſon why the Ordinates found by the late Mr. *Hawkſbee*, in examining the Curve produced in a contrary Situation, upon dipping two Glaſs Planes ſo join'd into Spirit of Wine, do not anſwer to thoſe of the Hyperbola. Fig. 199.

Exp. 4. AB is a Perpendicular Section through two Glaſs Planes join'd at A, and open'd to a ſmall Angle at B. C repreſents a pretty large Drop of Mercury, the larger the better, which being made to deſcend as far as C, by holding the Planes in an erect Poſture, with the End A downwards, retires from the Contact of the Planes to D, upon inclining the Planes towards an horizontal Situation; and the Fig. 200.

Diſtance C D becomes greater or leſs, as the Planes are more or leſs inclin'd towards the Horizon.

A Drop of any Oily or Watery Liquor moves the contrary Way, as has been ſhewn by the late Mr. *Hawkſbee*.

Fig. 201. *Exp.* 5. A B is a Tube open at both Ends, and a Foot or two in Length, whoſe lower Part is drawn out into a fine Capillary at B. This Tube being filled with Mercury, the whole Column of Quickſilver will be ſuſtained in it, provided the Capillary Tube at B be ſufficiently ſmall. But if the Mercury in the End B be ſuffer'd to touch any other Mercury, it runs all out of the Tube. If, without letting it touch any other Mercury, a ſmall Part of the End B be broken off, the Mercury will run out, till it comes to ſome leſſer height as B C, at which it will again ſtop, the height B C being nearly in a reciprocal Proportion to the Diameter of the ſmall End of the Tube.

The Seventh Experiment in the former Paper is the Reverſe of this.

Fig. 202. *Exp.* 6. Is the ſame in Subſtance with the former, but made with a large Glaſs Funnel AB, inſtead of a Tube.

The Reverſe of this in Water is the thirteenth Experiment in the former Paper.

In all theſe Experiments it is eaſily ſeen, that the Effect is owing to the Difference between the two Attractions, by which Mercury tends to Glaſs and to its own Body; they being always oppoſed to one another, ſo that a particular Explication is no Way neceſſary. But perhaps it may ſave ſome little Trouble to the Reader, to remove the following Objection, which will readily occur to him.

In the Experiments brought to demonſtrate the fourth Propoſition, the Globule of Mercury adheres to the Glaſs in a Plane Surface, which cannot be done without increaſing the Surface of the Globule, and conſequently removing ſome of its Particles from the Contact of one another. If therefore they tend more ſtrongly to one another than to the Glaſs, why do they not recede from the Glaſs, and aſſume a Figure perfectly Spherical, that they may all have the greateſt poſſible Contact with each other?

To this we may anſwer, That the Power, by which Mercury is attracted either by Glaſs, or by other Mercury, is proportional to the attracting Surface; and therefore, though, *cæteris paribus*, the Tendency of Mercury to Glaſs, is not ſo ſtrong as its Tendency to other Mercury, yet in this Caſe a much greater Number of Mercurial Particles coming into Contact with the Glaſs, than what recede from the Contact of one another, it is no Wonder that the Attraction of the Glaſs prevails, and cauſes the Globule to adhere to it. For the Number of Mercurial Particles, which loſe their Contact with the other Mercury, is no more than what makes up the Difference of Surface, which ariſes from changing the Figure of the Drop: Whereas the Particles, which by this Means come to adhere to the Glaſs, are all thoſe that conſtitute the plane Surface, in which the Globule touches it.

Which Conſideration ought likewiſe to be apply'd to the Suſpenſion of Quickſilver in Glaſs-Tubes, either at extraordinary heights in the open Air, or at leſſer heights in a *Vacuum*, as above-mentioned. For the Top of the Tube being Spherical, or nearly ſo, it will be found, that the Contact of the Mercury with the Extremity of the Tube, is to the Contact with other Mercury, which would be gained by its leaving the Top of the Tube, and deſcending a very ſmall Space, in a *Ratio* infinitely great; and conſequently that the Contact of the Mercury with the Top of the Tube is one Cauſe of its Suſpenſion.

Corol. 1ſt. From this Propoſition it appears, that in a Barometer made with a narrow Tube, the Quickſilver will never ſtand at ſo great a height as in a wider. Which accounts for the *Phænomenon* ſo often mentioned, in the yearly Hiſtory of the Royal Academy of Sciences at *Paris*, by Monſ. *De la Hire*; that in the Barometer, which he conſtantly made uſe of for his annual Obſervations, the Quickſilver did not riſe ſo high, as in another he kept by him, by about three Lines and a half, which is near a third of an Inch our Meaſure: For he tells us, that the Tube of his Barometer is very ſmall. So that there is no need to have recourſe to any Peculiarity, either in the Quickſilver or the Glaſs of which that Tube was made; or to an unperceived Remnant of Air left in the Tube, from ſome of which Cauſes that Effect, and ſome others of the ſame kind, were imagined to proceed.

Corol. 2d. In a Barometer made with a ſmall Tube, the Mercury will riſe and fall irregularly. For, as the height of the Mercury depends partly upon the Diameter of that Part of the Tube that touches the upper Surface of the Mercury; it is plain, that the unavoidable Inequalities in the Diameter of the Tube will be more conſiderable, in reſpect to the whole Diameter; and conſequently will affect the height of the Mercury, more in a ſmall Tube than in a wider. And this I take to be the Reaſon, why it is ſo very difficult, not ſo ſay impoſſible to make two Barometers which ſhall exactly agree in the height of the Quickſilver in all Conſtitutions of the Air, eſpecially if the Tubes be very narrow. This Irregularity is ſtill more conſiderable in the Pendent Barometer, in which the Quickſilver moves through a large Space in order to make a ſmall Alteration in the length of the Column ſuſpended. The ſame Conſideration is eaſily extended to thoſe Levels, that depend upon the riſing of Mercury to the ſame height, in the oppoſite Legs of a bent Tube, an Inſtrument of which kind has been lately offered. And as the Effect is juſt contrary in Levels made with Water or Spirit of Wine, due Regard ought to be had to this Property in the Conſtruction of thoſe Inſtruments, by making the Tubes ſufficiently wide, in order to diminiſh the Error as much as poſſible.

IV. We often ſee the Motion of Water, when it runs out at a Hole in the Bottom of a Veſſel, to be compared with other Powers, not only in Hydraulicks, but in the Application of its Principles to the Animal

Of the Motion *of* Running Waters, *by the* ſame, n. 355. p. 748.

Oeconomy. The Quantity of which Motion as no one that I know of has hitherto rightly determined, in its Place the Writers on Hydraulicks are uſed to have Recourſe to the Weight of a Column of Water incumbing on the Hole. They that do this do not conſider, that no Motion can be compared with a Weight at reſt. Now the Motion of running Water may eaſily be determined after the following Manner.

Fig. 203. Let *SHAHS* be the indefinite Superficies of Water, *CC* a circular Hole made at the Bottom, *AB* a perpendicular right Line drawn through the Center of the Hole, *SGCCGS* a Column or Cataract of Water running through the Hole *CC*, *SGC* a Curve by the Rotation of which about the Axis *AB* a Solid is generated, or the Cataract *SGCCGS*. For when Water deſcends freely, and by an accelerated Motion like all heavy Bodies, it will be neceſſarily contracted into a leſſer Space, as it acquires a greater Velocity by falling, and flows out of the Hole *CC* with ſuch a Velocity as is acquired by falling from the Height *AB*.

But the Velocity of a heavy Body acquired by falling, as has been demonſtrated by *Galilæus*, is in a ſubduplicate Ratio of the Altitude from from whence it falls. Wherefore if any Ordinate *DE* be drawn to the Curve *SGC*, and this be call'd y, and *AD* be made x; the Velocity of the Water in the Section *EE* will be expounded by $\sqrt{x}$, and the Product of that Velocity drawn into the Section it ſelf, will be $yy\sqrt{x}$.

This Product is as the Quantity of Water paſſing through that Section in a given Space of Time; and as the ſame Quantity of Water in a given Time paſſes through all the Sections of the Cataract, that Product will always be the ſame, and will be $yy\sqrt{x}=1$, or $xy^4=1$.

This is the Equation of the Curve *SGC*, Part of which (comprehended within a given Veſſel,) the great *Newton* has delineated, and has plainly indicated its Equation, *Prop.* 32. *L.* 2. of his *Principia*; and is the firſt who has explained to the learned World the true Velocity of running Water, derived from its genuine Principles.

The Curve itſelf is an Hyperboloid of the fourth Order, one of whoſe Aſymptotes is the right Line *AS* parallel to the Horizon, the other is *AB* perpendicular to the ſame.

The Power of which is the Quadrato-Cube of the Ordinate *FG*, drawn at the Point *G*; where the right Line *AG*, biſecting the Angle contained by the Aſymptotes, meets the Curve.

The Space *SADES*, included between the Curve *SGE*, the Ordinate *DE*, and the Aſymptotes *AD*, *AS*, is equal to four Thirds of the Rectangle *HD*, contained by the Abſciſs *AD* and the Ordinate *DE*. And therefore the Space *SHE* is one third Part of the ſaid Rectangle.

The Solid *SGEEGS*, generated by the Rotation of the Space *SADES* about the Axis *AD*, is double to the Cylinder incumbing on the Section *EE*. Whence the Concave Solid, which the Space *SHEGS* produces by its Converſion about the ſame Axis, is equal to the incumbent Cylinder. All which Things are eaſily found by the inverſe Method of Fluxions.

Theorem 1. If Water runs out of a Veſſel of an infinite Extent, through a circular Hole made at the Bottom, the Motion of the whole Cataract of Water towards the Horizon is equal to the Motion of a Cylinder of Water, under the Hole itſelf and the Altitude of the Water, whoſe Velocity is equal to the Velocity of the Water running through the Hole; or is equal to the Motion of a Quantity of Water which runs out in any given Time, of which the Velocity is the ſame as that, by which a Space equal to the Altitude of the Water may be deſcribed in the ſame given Time.

Demonſtration of the firſt Part. To the Curve *S G C* let another Ordinate *d c* be drawn as near the former *D E* as may be.

The Curve being converted about the Axis *A B*, the Ordinates *D E*, *d e*, will generate two Circles, between which the naſcent Solid *E E e e* will be intercepted. That Solid is equal to the Product of the Altitude *D d* drawn into the Section *E E*; and its Motion is equal to the Product of the Solid itſelf drawn into the Velocity of the ſame, or to the Product of the Altitude *D d*, the Section *E E*, and the Velocity of the Water in that Section. And ſince it is ſhewn above, that the Product of any Section of the Cataract and the Velocity of the Water in that Section, is a conſtant Quantity; the Motion therefore of the whole Cataract will be equal to the Product of that conſtant Quantity drawn into the Sum of all the Altitudes *D d*, or into *A B*, that is, to the Motion of the Cylinder under the Hole itſelf, and the Altitude of the Water, whoſe Velocity is equal to the Velocity of the Water flowing through the Hole. *Q. E. D.*

Corol. 1. The Altitude of the Water being given, the Motion of the Cataract will be in the Ratio of the Aperture.

2. The Aperture being given, the Motion of the Cataract will be in a ſeſcuplicate Ratio of the Altitude, or in a triplicate Ratio of the Velocity, with which the Water runs through the Hole.

3. The Motion of the Cataract being given, the Aperture will be reciprocally in a ſeſcuplicate Ratio of the Altitude, or in a triplicate Ratio of the Velocity reciprocally.

Demonſtration of the ſecond Part. The Quantity of Water running in a given Time is to the Cylinder under the Aperture, and Altitude of the Water, as the Space which Water running out with an equable Velocity will deſcribe in that given Time, is to the Altitude of the Water. And ſince the Velocity which is communicated to the Quantity of flowing Water is to the Velocity of the Cylinder in the ſame Ratio reciprocally, the Quantities of the Motions on each ſide will be equal. *Q. E. D.*

Corol. 1. The Altitude of the Water and the Quantity running out being given, the Motion of the Cataract is in a reciprocal Ratio of the Time, in which that Quantity runs out.

2. The Altitude and Time being given, the Motion of the Cataract will be as the Quantity of Water running out in that Time.

3. The Time and Quantity of the running Water being given, the Motion of the Cataract will be as the Altitude.

4. The Motion of the Cataract and Altitude being given, the Quantity of the Water is as the Time.

5. The Motion of the Cataract and Quantity of running Water being given, the Altitude is at the Time.

6. The Time and Motion of the Cataract being given, the Quantity of running Water will be reciprocally as the Altitude.

Fig. 204. *Theorem* 2. If *B A* be taken to *B D*, as DG^4 to $DG^4 - BC^4$; and if the Water runs out of a given Cylindrical Veſſel *G G E E*, which is always full, through a circular Aperture *C C* made in the Middle of the Bottom; the Motion of the Cataract of Water towards the Horizon will be equal to the Motion of the Cylinder under the Aperture and Altitude *A B*, whoſe Velocity is equal to the Velocity of the Water going out at the Aperture. Or it will be equal to the Motion of the Quantity of Water which flows out in any given Time, of which the Velocity is ſuch by which a Space may be deſcribed in the ſame given Time equal to the Altitude *A B*.

Demonſtration of the firſt Part. Let *A S* be drawn parallel to *D G*, and with Aſymptotes *A S*, *A B*, through the Points *G*, *C*, let *Newton*'s Curve *S G C* be ſuppoſed to be deſcribed.

That the ſame Altitude of the Water may continue, the Place of that which runs out muſt be ſupply'd with the Cylinder of Water *g g G G*, which deſcends with that uniform Velocity which is acquired by falling from *A* to *D*; as the aforeſaid excellent Author teaches us in that Propoſition.

The Motion of the Cataract *S S G G* is equal to the Motion of this Cylinder, by the foregoing Theorem. Therefore the Motion of the deſcending Water, being compounded of the Motion of the aqueous Cylinder *g g G G*, and of the Motion of the Cataract *G G C C*, will be equal to the Motion of the whole Cataract *S G C C G S*, that is, by the firſt Theorem, to the Motion of the aqueous Cylinder under the Aperture and Altitude *A B*, the Velocity of which is equal to the Velocity of the Water running out at the Aperture. *Q. E. D.*

The ſecond Part follows from the firſt.

Corol. 1. Hence ariſe all the Corollaries of the foregoing Propoſition, by ſubſtituting the Altitude *A B*, for the Height of the Water.

2. If the Veſſel was of a Figure different from a Cylinder, or the Figure of the Aperture inſtead of Circular was Square, Triangular, or any other, or the Aperture were not in the Middle, or were in the Side of the Veſſel, the Motion of the Cataract will be the ſame, that is, equal to the Motion of an aqueous Priſm under the Aperture and Altitude *A B*, whoſe Velocity is equal to the Velocity of Water running out. For the ſame Quantity of Water will paſs with the ſame Velocity as in the former Hypotheſis, both through the Aperture itſelf, as alſo through all the Sections of the Cataract.

3. If the Diameter of the Veſſel ſhould have a very large Ratio to the Diameter of the Aperture, the Altitude *A D* might be neglected, and the Altitude of the Veſſel itſelf might be uſed for the Altitude of the Cylinder, or of the aqueous Priſm.

Hitherto we have conſidered only that particular Caſe, in which the Water runs out of the Veſſel by the Force of its Gravity. This we did the more willingly, as well becauſe Mathematicians are commonly uſed to admit that only, when they treat of the Impetus of Fluids, as alſo becauſe we think that Property of the Hyperbolical Curve above explained, in which it forms a Cataract of deſcending Water, not to be unworthy of the Conſideration of Geometricians. Otherwiſe that Caſe might have been eaſily deduced from the general Theorem, which we ſhall next propoſe.

Theorem 3. If Water flows through any full Canal *A B C D*, according to the Line *E F*, to which both the Orifices of the Canal *A B* and *C D* are perpendicular; the Motion of the Water towards the Orifice *C D*, or the Motion of the Impediment, which being oppoſed in the Orifice itſelf, ſtops the Motion of all the Water, is equal to the Motion of an aqueous Priſm under any Section of the Canal *C H*, and the Line of Direction or the Length of the Canal *E F*, which is moved with the ſame Velocity with which the Water flows through that Section; or is equal to the Motion of a Quantity of Water which in any given Time flows out of the Canal, the Velocity of which is the ſame by which a Space equal to the Length of the Canal may be deſcribed in the ſame Time. Fig. 205.

Caſ. 1. Let the Line of Direction be any right Line *E F*.

The firſt Part is eaſily demonſtrated in the ſame manner as the firſt Theorem. For the Product of any Section of the Canal *C H*, and of the Velocity of the Water in that Section, is a conſtant Quantity.

The ſecond Part follows from the firſt.

Caſ. 2. If the Line of Direction *ABCDE* is compounded of ſeveral right Lines *AB*, *B C*, *C D*, *D E*, inclined to each other, the Motion of the Water will be the ſame. For the Motion of the Water in the whole compounded Canal *A B C D E* is made up of the Motions of the Water in the Parts of the Canal *AB*, *BC*, *C D*, *D E*, added together. Now it is determined, that Water running according to the right Line *AB*, if it changes that Direction into another, by which it proceeds according to the right Line *B C*, loſes none of its Motion. For Fluids do not obſerve the Laws which are obſerved in the Motion of ſolid Bodies, whenever their Direction is changed. Otherwiſe a Fluid would quite ſtop, when it changes its Direction into another Perpendicular to the former, which we do not find by Experiments. Wherefore Water running out of a Hole in a Veſſel, whether downwards, or horizontally, or if it is forced directly upwards, maintains the ſame Velocity. Now if at any time it ſhould be diſcover'd, either by Experiment or by ſome ſtricter way of reaſoning, that any Change of Motion ſhould Fig. 206.

follow from a Change of Direction, then an Account muſt be taken of it.

Fig. 207. If the Line of Direction *A B* be a Curve, it muſt be refer'd to this Caſe, as it is to be conceived as compoſed of many little right Lines.

Fig. 208. *Caſ.* 3. If the Canal *A B* is divided into ſeveral Branches *B C*, *B D*, *B E*, equal in Length, the Motion of the Water will be found after the ſame Manner, taking for the Line of Direction the Length *A B D*, compounded of the Length of the principal Canal *A B*, and the Length of each Branch *B D*. Now it is all one whether the Water flows from the principal Canal towards the Branches, or from the Branches towards the principal Canal. Now if the Branches are unequal, the Motion of the Water muſt be found in each Branch, taking for the Line of Direction a Length compoſed of the Length of each Branch, and the Length of the principal Canal.

This is eaſily deduced from the ſecond Caſe.

Fig. 209. *Caſ.* 4. If the unequal Branches into which the Canal *A B* is diſtributed, are again united into one *F G*, to find the Motion of the Water for the Line of Direction we muſt make uſe of the whole Length *A B D F G*, compos'd of the Length of the principal Canal *A B*, of each Branch *B D F*, and of the recompounded Canal *F G*. If the Branches are unequal, the Motion of the Water muſt be found in each, and the Sum of their Motions muſt be added to the Motion of the Water in the recompounded Canal. This follows from Caſ. 2 and 3.

Corol. 1. The Length of the Canal being given, and any Section of the ſame, the Motion of the Water will be in the Ratio of the Velocity with which the Water flows through that Section.

2. Any Section being given, and the Velocity of the Water flowing through that Section, the Motion of the Water will be as the Length of the Canal.

3. The Length of the Canal being given, and the Velocity of the Water in any Section, the Motion of the Water will be in the Ratio of that Section.

4. The Motion of the Water being given, and alſo any Section, the Length of the Canal will be in the reciprocal Ratio of the Velocity.

5. The Motion of the Water being given, and the Length of the Canal, any Section will be reciprocally as the Velocity.

6. The Velocity being given in any Section, and the Motion of the Water, that Section will be reciprocally as the Length.

7. The Length of the Canal being given, and the Quantity of Water running out in any certain Time, the Motion of the Water will be reciprocally as that Time.

8. The Length of the Canal, and the Time being given, the Motion of the Water will be as the Quantity running out.

9. The Time being given, and the Quantity of Water running out, the Motion of the Water will be as the Length of the Canal.

10. The Motion of the Water, and the Length of the Canal being given, the Quantity flowing out will be as the Time.

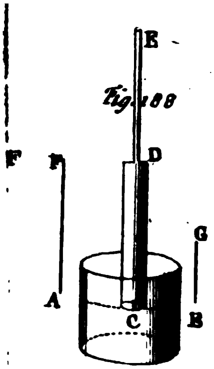


Fig. 188

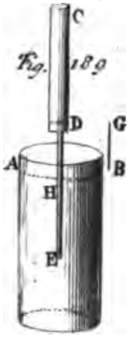


Fig. 189

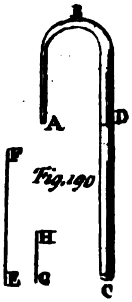


Fig. 190

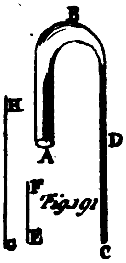


Fig. 191

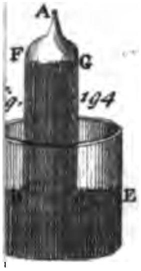


Fig. 194

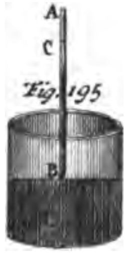


Fig. 195

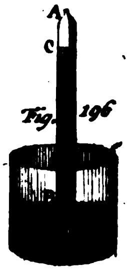


Fig. 196

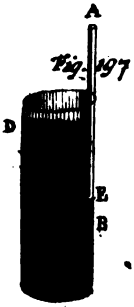


Fig. 197

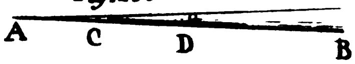


Fig. 200

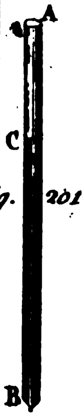


Fig. 201

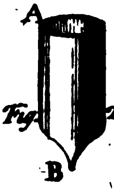


Fig. 202

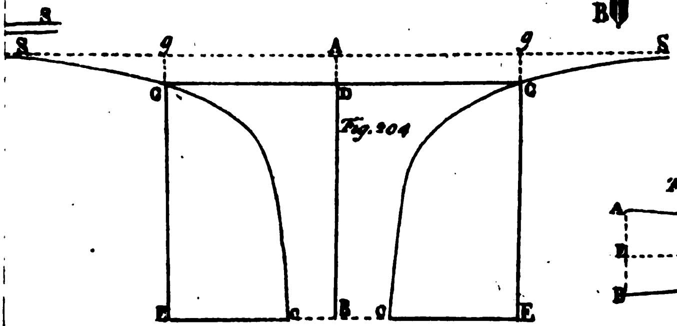


Fig. 204

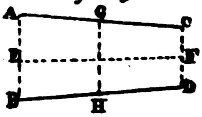


Fig. 205

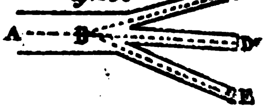


Fig. 208

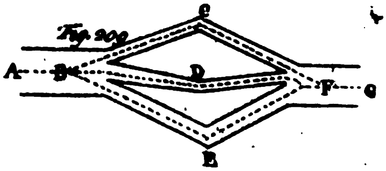


Fig. 209

11. The Motion of the Water, and the Quantity running out being given, the Time will be as the Length of the Canal.

12. The Time being given, and the Motion of the Water, the Quantity running out will be reciprocally as the Length of the Canal.

13. If two Quantities of Water meet directly with a contrary Motion, and the Superficies with which they impinge are alike, as alſo the Velocities with which thoſe Superficies meet; and if one of the Quantities of Water is only equal to one little Drop, and the other Quantity is a whole Ocean, or an infinite Quantity of Water; it may be ſo order'd that the Drop ſhall ſuſtain the whole Ocean, or force it to move the contrary Way with the ſame Velocity as before, and it ſelf ſhall proceed the ſame Way after meeting. Which is a wonderful Paradox in Hydraulicks.

14. If a certain Quantity of Water flows through a Canal which is compoſed of two cylindrical Tubes of unequal Diameters, and runs from the larger Tube towards the narrower; and the Motion of the Water is neither leſſened nor increaſed as it flows; as ſoon as the firſt Part of the Water ſhall enter at the Beginning of the leſſer Tube, it will immediately begin to run ſlower, and by a continual Efflux out of the wider Tube into the narrower, the Water by Degrees will be more retarded in the narrower Tube, till the whole ſhall come into that Tube. The Matter will happen juſt on the contrary, when the Water flows out of the leſſer Tube towards the wider. This is another Paradox in Hydraulicks. But the Water is ſuppoſed every where to cohere with it ſelf.

Theſe two Corollaries ariſe from Caſe 1.

—*Of the* Motion *of the* Blood *in the* Arteries.

15. From Caſe 2 a Method is ſupply'd for eſtimating the Motion of the Blood in any of the Arteries.

16. Any two Arteries being given that tranſmit an equal Quantity of Blood, the Impetus of the Blood is greater in that which is more remote from the Heart, than in the nearer. This is a remarkable Paradox in the Animal Oeconomy.

17. From the third Caſe ariſes another Paradox in the Animal Oeconomy, that the Motion or Impetus of the Blood is greater in all the capillary Arteries taken together, than in the Aorta it ſelf. Alſo that it is greater in the capillary Veins than in the Arteries.

18. From the fourth Caſe a Method is derived of determining the Motion of the Blood in any of the Veins.

19. From the ſame is derived a third Paradox in the Animal Oeconomy, that the Impetus of the Blood is greater in any Vein, than in the Artery correſponding to that Vein; and therefore that it is greater in the Vena Cava than in the Aorta.

—*Of the* Motion *of the* Air *flowing out of the* Lungs *in* Expiration.

Problem I. To find the Motion of the Air ruſhing out of the Lungs.

Let l be the Length of the whole Aerial Duct, from the Mouth and Noſtrils to the furtheſt Branches of the Trachea.

$q =$ to the Quantity of Air emitted from the Lungs at a moderate Expiration.

$Q =$ to the Quantity expell'd at a very moderate Expiration.

$t =$ to the Time of a moderate Expiration.

$T =$ to

T = to the Time of a very ſtrong Expiration.

Then by *Theor.* 3. *Caſ.* 3. the Motion of the Air ruſhing out of the Lungs at a moderate Expiration will be $= \frac{ql}{t}$.

At a very ſtrong one will be $\frac{Ql}{T}$.

That is, the Motion of the Air ruſhing out of the Lungs is equal to the Motion of the Quantity of Air which is emitted at one Expiration, of which the Velocity is the ſame, by which the Length of the whole Aerial Canal is deſcribed in the Time of an Expiration. *Q. E. I.*

The famous Philoſopher *Alphonſus Borellus* has determin'd by Experiment, that the Quantity of Air emitted by a moderate Expiration is about 18 or 20 cubical Inches. Now it is different not only in different Men, but in the ſame Man at different Times. I have made an Experiment after this manner.

I hung a Weight to the lower End of a wet Bladder, and fitting a Glaſs Tube to the upper Part of about an Inch Diameter, ſtopping my Noſe I breath'd Air gently into the Bladder, for the Space of three Seconds, the Weight in the mean time being at Reſt upon the Table. Afterwards I dipt the Bladder, with the Air included and the Weight hanging to it, into Water that was contain'd in a cylindrical Veſſel, carefully obſerving to what Height the Water was raiſed, When this was done the Quantity of Water was eaſily found, which being poured into the Veſſel aroſe to the Height before obſerved. This Experiment being repeated ten times, and the Quantities being added together which were found at each Time, their tenth Part, or the mean Quantity of Water contain'd in the Veſſel, was found to be equal to 35 cubical Inches. And this is the Quantity of Air contain'd in the Bladder; then adding about one twelfth Part, or three cubical Inches, becauſe of the Condenſation of the Air made by the Coldneſs of the Water, it being then Winter-Seaſon, it becomes 38 cubical Inches. Beſides a little muſt be added, both becauſe of the Preſſure of the Water in the Bladder, as becauſe of the Vapour which is ſent forth with the Breath into the Moiſture ſqueezed together; which muſt neceſſarily be from the Coldneſs of the Water, and the Contact of the wet Bladder. Therefore I eſtimated the Quantity of Air that was emitted by gentle Expiration in the Time of three Seconds, in a round Number of 40 cubical Inches.

By a very ſtrong Expiration I emitted 125 cubical Inches in the Time of one Second.

And by ſuch a very ſtrong Expiration, with a violent ſtraining of the Lungs, continued almoſt to choaking, I emitted from my Breaſt 220 cubical Inches. Whence it is plain, which I ſhall take notice of by the bye, that much more Air remains in the Lungs than is emitted at one moderate Expiration.

If therefore we ſuppoſe $l = 2$ Feet,

$q = 40$ cubical Inches,
$Q = 125$ cubical Inches,
$t = 3$ Seconds,
$T = 1$ Second,

The ſpecific Gravity of Air to the Gravity of Water, as 1 to 1000,
A cubical Foot of Water = 1000 Ounces Avoirdupois,

The moderate Motion of Air going out of the Lungs will be equal to the Motion of the Weight of four Scruples and nine Grains, which moves one Inch in a Second; or to the Motion of a Weight of $1\frac{1}{3}$ Grain, which in the ſame Time deſcribes the Length of 5 Feet and 7 Inches. This is the Velocity of the Air ruſhing through the Larynx, ſuppoſing the Section of the Larynx equal to one fifth of a ſquare Inch.

The greateſt Motion of the Air expell'd out of the Breaſt is equal to the Motion of a Weight of about $1\frac{1}{4}$ of an Inch, deſcribing one Inch in a Second; or to the Motion of a Weight of $1\frac{1}{3}$ of a Grain, deſcribing 52 Feet in the ſame Time. This is the Velocity of the Air ruſhing through the Larynx in the ſtrongeſt Expiration.

Corol. 1. The Quantity of Air being given, and the Length of the Aerial Canal, the Motion of the Air is in a reciprocal Ratio of the Time of Expiration.

2. The Quantity of Air and the Time being given, the Motion will be in a direct Ratio of the Length.

3. The Length and Time being given, the Motion is as the Quantity of Air.

4. The Motion and Quantity of Air being given, the Length will be in the direct Ratio of the Time.

5. The Motion and Length being given, the Quantity of Air will be directly as the Time.

6. The Motion and Time being given, the Quantity of Air will be reciprocally as the Length of the Aerial Canal.

7. The Motion of the Air is in a Ratio compounded of the quadruplicate Ratio of any homologous Diameter of the Animal, and the inverſe Ratio of the Time of Expiration. Or in a Ratio compounded of the Ratio of the whole Weight of the Animal, a ſubtriplicate Ratio of its Weight, and the reciprocal Ratio of the Time.

For the Weight of the Animal, the Cube of any homologous Diameter and the Quantity of Air expell'd are in the ſame Ratio. Now it is ſuppos'd, that the Bodies of Animals are Machines made after the ſame manner.

Scholium. You are to underſtand the Length here made uſe of to be either the Length of the Aerial Canal, if all the Branches of the Trachea are ſuppos'd equal in Length, or the mean one between the different Lengths, if the Branches are unequal.

Problem II. To determine the Impetus, or the Impreſſion, which the internal Surface of the Lungs receives by expiring the Air.

Since Action and Reaction are equal and contrary, it muſt neceſſarily follow, that by whatever Motion the Air to be expired is urged by the internal Superficies of the Lungs, by the ſame on the contrary the Superficies of the Lungs is repell'd by the Air.

Whence by the foregoing Problem the ſaid Impetus in a moderate

Expiration will be equal to $\frac{ql}{t}$,

in a very ſtrong one it will be equal to $\frac{Ql}{T}$. *Q. E. I.*

Hence ſuppoſing the ſame Things as are ſuppos'd above, the moderate Impetus of the Air upon the Lungs is equal to the Motion of about 1½ Drachm, which in the Space of a Second deſcribes one Inch. Or to the Motion of the Weight of 19 Pounds, moving $\frac{1}{1641}$ of an Inch in the ſame Time, which is the Velocity of the Air in Contact of the inward Superficies of the Lungs. But we ſuppoſe with the very learned Dr. *James Keil*, that the internal Superficies of the Lungs is equal to about 21900 ſquare Inches.

But the greateſt Impetus of the Air upon the Lungs is equal to the Motion of the Weight of about 1¼ Ounce, moving one Ounce in a Second; or to the Motion of the Weight of 19 Pounds, which deſcribes the $\frac{1}{175}$ Part of an Inch in the ſame Time. This is the Velocity of the Air at the Superficies of the Lungs in a violent Expiration.

Corol. 1. The Corollaries ſubjoin'd to the foregoing Propoſition follow from hence.

2. A moderate Impetus incumbing upon a Part of the Surface of the Lungs, which is equal to the Section of the Larynx, is the Motion of the Weight of $\frac{1}{1232}$ of a Grain deſcribing the Space of an Inch in a Second; or the Motion of the Weight of 1⅓ of a Grain, which deſcribes the $\frac{1}{1642}$ Part of an Inch in the ſame Time. But the greateſt Impetus upon an equal Superficies is the Motion of the Weight of the $\frac{1}{131}$ Part of a Grain, which deſcribes one Ounce, or the Motion of the Weight of 1⅓ of a Grain, which makes $\frac{1}{175}$ Part of an Inch in every Second of Time.

3. The Impetus of the Air in a moderate Expiration impreſs'd upon the Lungs, is equal to the Motion of a Column of Water that runs one Inch in a Second, the Baſe of which Column is the internal Surface of the Lungs, and its Height is $\frac{1}{68138}$ of an Inch. And in the moſt vehement Expiration of all, the Altitude of the Column is the $\frac{1}{7300}$ Part of an Inch.

4. The Impetus incumbent upon a Superficies equal to a great Circle of a Globule of Blood, in a gentle Expiration, is the $\frac{1}{14}$ Part of the Weight of a Globule of Blood, in a vehement Expiration it is $\frac{2}{3}$ of the ſame Weight moving one Inch in a Second. But by the way I think fit to explain after what manner I meaſur'd the Diameters of the Globules of Blood, ſince it may be of Uſe for determining the Magnitudes of other minute Objects. I took a fine Hair which was pretty long, and wound it ſeveral times about a fine Needle, ſo that all the Convolutions

might exactly touch one another, as I could plainly perceive by the Help of a Microſcope. Then I took with my Compaſſes the Diſtance between the extream Circumvolutions on each Side, and apply'd it to a Diagonal Scale, and divided the Space found by the Scale by the Number of Circumvolutions. Whence was found the Breadth of one Circumvolution, or the Diameter of the Hair. Then I cut the ſame Hair into a great Number of very ſmall Parts, and ſcatter'd them on the Plain of my Microſcope, on which a little Blood had been ſmear'd ſo as that the Globules might be diſtinctly diſcern'd. When I look'd upon them with my Microſcope, in ſome Places I found the Bits of Hair ſo conveniently diſpoſed, that I could count how many Globules were oppoſed to the Diameter of a Segment or Bit of Hair. But the Segments were unequal in Diameter, becauſe the Hair was ſlenderer towards its Extremity than nearer the Root, ſo that ſometimes 7 or 8, ſometimes 12 or 13 Globules anſwer'd to a tranſverſe Section of the Hair. Now when both Experiments were often repeated, at laſt I eſtimated the mean Diameter of the Hair at the $\frac{1}{324}$ Part of an Inch, and the Diameter of a Globule of Blood at a tenth Part of the Diameter of the Hair, or at the $\frac{1}{3240}$ Part of an Inch.

5. The Impetus which is ſuffer'd by the internal Superficies of the Lungs by expiring the Air, is leſs than the Motion of the mildeſt Particle of Dew falling from the Heaven.

Scholium. In the Solution of the two foregoing Problems the Conſideration is neglected of that Impediment, which the Air ſuffers at its going out of the Lungs, by its Friction againſt the Sides of the Artery Trachea and its Branches; ſince it is but little, nor can it be eaſily eſtimated exactly by any Experiment. Nor have we been very ſolicitous about keeping nicely the Ratios of the Numbers, ſince the only thing we propoſed was, to explain the Method of eſtimating thoſe Forces, ſomething more certainly than has hitherto been done, by which in Expiration the Air acts upon the Blood-veſſels, that involve the internal Superficies of the Lungs. Whence it may be known, whether thoſe Forces are ſufficient to produce thoſe Effects, which are attributed to them by ſome very learned Writers on Medical Subjects.

—*Of the* Motion *of the* Blood, *&c.*

Problem III. To determine the Impetus of the Blood, in the Vena Cava, near the right Auricle of the Heart; or the Motion of the Blood flowing through all the Arteries and the Veins, except the Veins of the Lungs.

Let q denote the Quantity of Blood projected into the Aorta, by one Syſtole of the Heart.

$l =$ to the mean Length of the intire Arterio-venous Duct, taking in both the longer and ſhorter Branches.

$t =$ to the Time between two Pulſes,

Thence by Theor. 3. Caſ. 4. the Impetus required $= \frac{ql}{t}$.

That is, the Impetus of the Blood in the Vena Cava is equal to the Motion of the Quantity of Blood which is projected into the Aorta by one Syſtole, of which the Velocity is ſuch, that the whole Length of the Arteries and Veins may be deſcribed in the Space of Time intercepted between two Pulſes. *Q. E. I.*

If in an human Body are ſuppoſed

$q = 2$ Ounces Avoirdupois,
$l = 6$ Feet,
$t = \frac{3}{4}$ Seconds,

The Impetus of the Blood in the Vena Cava will be equal to the Motion of the Weight of 12 Pounds, which deſcribes the Length of one Inch in a Second. Or to the Motion of the Weight of Pounds, which in the ſame Time deſcribes half a Foot. This is nearly the Velocity of the Blood flowing in the Cava. But we ſuppoſe, by the Menſuration of the learned Man above named, that a Section of the Cava is ¾ of a ſquare Inch.

Corol. All the Corollaries of the firſt Problem, changing what is to be changed, reſult from this Problem.

Problem IV. To determine the abſolute Motion of the Blood in the Vena Cava, or the Motion of the Blood flowing through all the Arteries and Veins, except thoſe of the Lungs; abſtracting from the Reſiſtance of the Veſſels.

Let the natural Velocity of the Blood be to that Velocity with which the Blood would flow, abſtracting from all Reſiſtance, as 1 to x. And whereas by the Corollary of the foregoing Problem, and Corol. 1. Prob. 1. the Motion of the Blood is in the Ratio of the Velocity, thence the Motion required is $= \frac{xql}{t}$. *Q. E. I.*

Now if the Proportion found by the Experiment made by the abovemention'd learned Man, be admitted as near the Truth, it will be $x = 2{,}5$.

Whence the ſame Things being ſuppos'd as above, the abſolute Motion of the Blood in the Vena Cava is equal to the Motion of the Weight of 30 Pounds, which deſcribes the Length of an Inch in a Second; or to the Motion of a Weight of 2 Pounds, deſcribing 1¼ Foot in the ſame Time. With this Velocity nearly the Blood moves through the Cava, abſtracting from all Reſiſtance.

Problem V. To find the Motion of the Blood in the Pulmonic Vein, near the left Auricle of the Heart, or the Motion of the whole Blood flowing through the Lungs.

Beſides the Characters uſed in Prob. 3. let λ be the mean Length of the Pulmonic Arterio-venous Canal.

Whence by Theor. 3. Caſ. 4. the Motion required is found $= \frac{q\lambda}{t}$.

That is, the Motion of the Blood flowing through the Lungs is equal to the Motion of the Quantity of Blood, which is projected at one Syſtole into the Pulmonic Artery, having that Velocity with which the Length of the Pulmonic Arteries and Veins may be deſcribed in the Time contain'd between two Pulſes. *Q. E. I.*

If in the human Body we ſuppoſe $\lambda = 1\frac{1}{2}$ Foot,

The Motion of the Blood in the Lungs will be equal to the Motion of the Weight of 3 Pounds deſcribing the Space of an Inch in a Second.

Problem VI. To determine the abſolute Moment of the Blood in the Pulmonic Vein.

By the ſame Argumentation as is uſed in Prob. 4. the Motion required will be found $= 2, 5 \times \frac{q\lambda}{t}$. *Q. E. I.*

The ſame Things being ſuppos'd as above, the abſolute Motion of the Blood flowing through the Lungs is equal to the Motion of the Weight of $7\frac{1}{2}$ Pounds, which every Second deſcribes one Inch.

Scholium. By the Experiment of Dr. *Keil* the Proportion is determin'd, which the natural Velocity of the Blood flowing through the Aorta and its Branches obtains, to the Velocity with which the Blood would flow through the ſame, abſtracting from the Reſiſtance of the Arteries and the preceding Blood. We have transfer'd the ſame Proportion to the Blood flowing through the Pulmonic Artery. Becauſe if we take away or diminiſh in any Ratio the Reſiſtance which the Blood ſuffers as it flows through each Artery, the Blood of neceſſity will be alike accelerated in each Artery. For unleſs it were ſo, the two Ventricles of the Heart would either not be contracted in the ſame Time, or would not eject the ſame Quantity of Blood. Either of which Things could not be done without the greateſt Perturbation and Danger of the whole Machine.

Corollary to the three foregoing Problems.

Hence follow the Corollaries ſubjoin'd to Prob. 5. *mutatis mutandis.*

Scholium to the four Problems above.

It is to be obſerved, that the Velocity of the Blood flowing as well through the Lungs as through the other Parts of the Body, though in reality it is not equable, yet here it is ſuppos'd to be ſo, that the mean Motion of the Blood may be found.

General Scholium. If any one ſhall think the Numbers not to be ſufficiently accurate, which are here interſperſed in ſpecious Characters, he may eaſily correct them by deriving other Numbers from Experiments that approach nearer to Truth, as alſo the aforeſaid Examples of Motions; or by the Aſſiſtance of the Corollaries of the Propoſitions themſelves.

V. I am buſy at preſent for a Coal-mine, which hath been left off becauſe of the Impurity of the Air; I have therefore improved the *Heſſian* Bellows: An Account of that Contrivance is printed *Lipſiæ* in *Actis Eruditorum anno* 1699. with this Title, *Rotatilis Suctor et Preſſor Heſſiacus:* And it may be applied for Wind as well as for Water. At that Time the Shape of the *Tympanum* was Cylindric, as may be ſeen *Fig.* 210. where *DAFC* is the Circumference: *CP*, *DP*, *AP*, are the *Radii* which bear the Wings *Cm*, *Dn*, *Ao*: *CE* is the Aperture through which the Wind muſt be driven in the Direction of the Tangent *CB*: And it may be obſerved, that when the Engine is working, every Wing from the End of

The Heſſian *Bellows improv'd, by Mr.* D. Papin. n. 300. p. 1990.

Fig. 210.

the Aperture *E*, till it comes to the Beginning of the ſame Aperture *C*, drives always the ſame Air, with the ſame Swiftneſs, and at the ſame Diſtance from the Center: So that in peruſing all that Circumference, the Air doth find Reſiſtance by Friction, and gets nothing at all. I do therefore now make the Circumference of the *Tympanum* in the Spiral Shape, Fig. 211. which is to be ſeen *Fig.* 211, where the Spiral Circumference is *AFGB*, the *Radii* are *AP*, *CP*, *DP*, *&c.* The Wings are *AM*, *CN*, *DO*, *&c.* The Aperture is *AB.* And it is to be obſerved, that every Wing in going round drives new Air, becauſe the Air which is firſt in Motion finds Place to recede from the Center towards the Spiral Circumference; and ſo it gives room to new Air to come to the Wing: And when the Wings come near to the Aperture, they drive their new Air into the Aperture without any Friction; and the Air which hath been firſt driven and removed from the Wing, cannot loſe its Swiftneſs, becauſe the Wings which continually follow do continually drive new Air, which keeps that which is before always in the ſame Swiftneſs. This new Shape of the *Heſſian* Bellows affords alſo another Advantage; becauſe the Air in going round follows the Spiral-line, which is nearer to the ſtrait Line than a circular Circumference; and when the Air comes to the Aperture, it gets into it without any Loſs of Subſtance; but in the Cylindrical Machine, the Air doth always go round in a circular Circumference, and when it comes to the Aperture, the Wind is driven directly in the Direction of the Tangent, but juſt in the Beginning at *C*; and afterwards the Impulſion is oblique: And this Obliquity is always increaſing until the Wing comes to the *punctum A:* Now it is known how much Diminution ſuch an Obliquity can make to the Strength. I believe therefore that this Spiral Figure is a good Improvement to this Engine. And indeed I have made ſuch Bellows, where the *Radius AP* is but 10½ Inches, the Wing *Am* 2 Inches broad and 9 Inches high; becauſe the *Tympanum* is alſo ſo high, or little more; the Aperture *AB* is alſo 9 Inches, or a little more, ſo that it makes a ſquare Hole. When I work this Engine with my Foot, it makes ſuch a Wind, that it may raiſe up two Pounds Weight; and without doubt, a ſtronger Man could do much more: But this is more than ſufficient for our Purpoſe, ſince we muſt but drive Air enough for the Reſpiration of ſuch Men that can work in the Mine; and we may eaſily with Boards make wooden Pipes, to carry the Wind to the very Bottom: So that the Air within will be continually renewed as well as without.

As to the Engine to demonſtrate the Power of Water expanded by Fire, we have here made very good Experiments of that Matter before Winter. We have raiſed Water to the height of 70 Foot, by a very commodious Way, which may be yet very much improved. The *Heſſian* Bellows may be very uſeful to a Furnace, I have already made a little Trial of it, and I had a very ſtrong Fire in a Furnace, to melt Glaſs, Iron, or any other hard Metal; and yet I could open the Furnace above the Matter to be wrought upon, and yet no Flame would get out through the Aperture; nor cold Air from without get into the Furnace: So that it is very like this will be a great Conveniency for ſeveral ſorts of Work, ſince Men may work the Matters when they are moſt ſoftened in the Fire; and they may be drawn up perpendicularly, that they may not be bent, as they are when we draw them horizontally. I believe that would be good, eſpecially to make eaſily Glaſs Pipes and Looking-Glaſſes of an extraordinary Bigneſs.

VI. *Account of a Book omitted.*

Joannis Poleni in Gymnaſio *Patavino* Phil. Ord. Prof. & Scient. Societatum Regalium, quæ *Londini* & *Berolini* ſunt, Sodalis, *De Motu Aquæ Mixto*, Libri Duo, *&c.* *4to.* *Patavii* 1717.

CHAP. VI.

Geography. Navigation.

I. SEveral Perſons have given us, as they have ſuppoſed, the juſt Number of Acres contained in *England*, or *South Britain*, or very near it. Sir *William Petty* reckons about 28 Millions; others, 29 Millions; others, a few more. But they have all been miſtaken in under-reckoning.

A Demonſtration of the Number *of* Acres *in* England, *by Dr.* N. Grew. n. 330. p. 266.

And the Reaſon of their Miſtakes ſeems to have been, their reckoning only by the Maps; that is, by computed, and not by meaſured Miles; by which only the Number of Acres can be known.

I have ſeen an Account of the Number of Acres in each County: Which Account, whether taken from Doomſday-Book, or from any other Regiſter, cannot be true. For tho' we have loſt ſome Land, yet there is a great deal more now gained, which in the Conqueror's Time lay under Sea. Within 120 Years, very much has been recovered out of the Seas, and maintained by Banks, in the Marſhes and Fenns of *Eſſex*, *Kent*, and the Iſle of *Ely*. And in ſome Parts of *Lincolnſhire*, the Land has gained of the Sea four Miles in a direct Line from Land to Sea, in the Memory of Men now living.

Nor is it the truer, for having been taken from any other Record: For if the Numbers of Acres, according to the ſaid Account, in each Shire, be put together, they exceed not 39 Millions and a Quarter; Which Number, though it comes much nearer to the Truth than any of the former, yet is a great deal ſhort of it.

For however, according to vulgar Computation, *England*, or *South Britain*, is reckoned in Length but 305 Miles; and in Breadth, about 290 Miles: Nevertheleſs, it appears by an exact Wheel-meaſure, That from *New-Haven* in the *South* of *England* to *London*, are 56 meaſured Miles; and that from thence by a ſtrait Line continued to *Berwick* in the *North*, are 339 of the ſame meaſured Miles; in all 395 meaſured Miles, the true Length of *England*. And again, that from the *South*

Foreland in the *Eaſt*, to the Land's End in *Cornwall*, are about 367 Miles of the ſame Wheel-meaſure, the true Breadth of *England*.

This being known, it is eaſy to know alſo, how many ſquare Miles and conſequently how many Acres are contained in *England*, or *South Britain*.

Fig. 212.

If a Line be drawn on a Chart of *England*, from the *South* Foreland in *Kent* to *Berwick*; and from the two Ends of this Line, two more Lines meeting at the Land's End in *Cornwall*, they will make the Triangle A B C: Which Triangle, as it excludes as much more of the Land, as it includes of the Sea, as may anſwer the ſmall Number of Miles obtained by the Curvity of the Roads; it may therefore be allowed to be equal to the Area of *England*, or *South Britain*.

Next, if to the Triangle A B C, another ſimilar and equal Triangle B C D, be added; both together make the Rhomboid A B D C. Which being divided at E F, maketh the Rhomboids A C E F, and B D E F, equal to one another. One of which is therefore equal to the Triangle ABC. And the Rectangle A G H F, ſtanding upon the ſame Baſe, and between the ſame Parallel Lines with the Rhomboid A C E F, by the 35th of the 1ſt of *Euclid*, is equal to the ſaid A C E F; equal to the Triangle A B C; equal to the Area of *England*, or *South Britain*.

Now the Length between *Berwick* and the South Foreland in *Kent*, being about 5 Miles more than between *Berwick* and *New-Haven*, which is 395 Miles: Therefore the Line A B, may be taken for 400 Miles; and ſo the Line A F, for 200. And the Line A G being leſs by about 7 Miles, than between the South Foreland in *Kent*, and the Land's End in *Cornwall*, which is 367 Miles, the ſaid A G may be taken for 360 Miles. Therefore A G, 360, being multiply'd by A F, 200, produceth 72000 ſquare Miles: And 72000 being multiplied by 640, the Number of Acres contained in one ſquare Mile, produceth 46 Millions and 80000, the Number of Acres contained in *England*, or *South Britain*.

Whence it appears, Firſt, that if the Province of *Holland* contains, as is computed, but one Million of Acres, then *England* is more, by a Fraction of 80000 Acres, than 46 times as big as *Holland*.

Next, if in the Province of *Holland*, containing but one Million of Acres, are two Millions and 400 Thouſand Souls, or two Millions and four 10ths, as they are ſaid to be; then *England*, which contains 46 Millions of Acres, to be proportionably populous, ſhould have twice 46 Millions of People, and four 10ths of 46; that is, about 110 Millions.

But to allow room enough for Perſons of all Degrees, if *England* were half as populous as *Holland*, with only 55 Millions, it were a good Proportion, and would be near five times our preſent Number: And about 22 times as many as in the Province of *Holland*.

To people *England* in a competent Time with this Number, there are many Ways practicable: By which, I have computed, the preſent Number may be doubled in 24 or 25 Years. And probably quadrupled in about 36 Years.

One of theſe Ways, though not the ſpeedieſt, would be the introducing of Strangers: Yet to make uſe of this, or of any other Way, to multiply the People, before we have provided the Means of employing them, would be prepoſterous.

But when we ſhall mind our true Intereſt, in employing and encouraging every where our own Hands, and the Hands of other Nations, as the *French* and *Dutch* do, in all the ſorts of Huſbandry, Manufactury, and Merchantry: When our Nobility and Gentry themſelves, ſhall be Examples in ſome or other of theſe Particulars: When we ſhall hereby be univerſally engag'd to incloſe, and to improve every Foot of our Land; to make the utmoſt Uſe of all our Home Growths, above and under Ground; and of all our Ports, (about 200 great and ſmall,) more than in all the Kingdoms and States of *Europe* put together: And when *Scotland* and *Ireland* ſhall both of them afterwards be improved in like Manner; when all Mens Heads and Hands ſhall be thus employ'd about ſome one honeſt and profitable Buſineſs, it is eaſy to foreſee how highly it will advance the *Britiſh* Monarchy and People, at Home, and all over the World, in Beauty, Strength and Glory.

II. I conclude that the Eclipſe of the Moon of *Dec.* 12*th* 1703. began at *London* at about 31 or 32 Minutes after 4 in the Morning.

At *Cambridge*, about 4 Miles from *Boſton* in *New England*, Mr. *Brattle* found, † that at 44 Minutes after 11 at Night, part of the Moon's Diſk looked ſomewhat duſkiſh, and that at 52 Minutes, the Shadow was well enter'd: So that from hence, as well as from a Compariſon of the Ingreſs and Egreſs of the principal Spots, it probably began there about 49 Minutes after 11; whence it follows, that *Cambridge* in *New England* lies $4^h\ 4'\ 2\frac{1}{2}$, or 70 37′, to the Weſtward of the Meridian of *London*.

The Difference of Longitude *between* London *and* Cambridge *in* NewEngland, *by Mr.* J. Hodgſon. n. 292. p. 1637.

† *Vid.* ſupra p. 271.

III. 'Tis now above thirty Years, ſince I had a Diſpute with ſome of the *French Geographers* about the Longitude of the Cape of *Good Hope*, ſaid to have been obſerv'd by the Religious Miſſionaries ſent to *China* in the Year 1685. By an Emerſion of the firſt Satellite of *Jupiter*, they determined that Cape to be $1^h\ 11'$, or $17\frac{3}{4}$ *gr.* more Eaſterly than *Paris*; that is, 20 *gr.* from *London*: Which, for the Reaſons I then gave, ‖ I concluded could not be more than 17 *gr.* Very lately I have fallen upon an Obſervation which I believe will determine the Controverſy in my Favour; for I had accidentally a Journal of an Officer of the Ship *Emperor*, put into my Hands, who in his Return from *India*, on the fifth of *March* 1718. obſerv'd the End of a Lunar Eclipſe, when the viſible Altitude of the Moon's Center was 13° 25, he being then in the Latitude of 34° 23 *South*, and as they found afterwards, juſt 180 Leagues to the Eaſtwards of Cape *Bonne Eſperance*. By Calculation I find, that in that Latitude, the Moon had that height at $7^h\ 17'\frac{1}{2}$ *P. M.* and by comparing this Eclipſe with that we obſerv'd with great Exactneſs on *Feb.* 11°; 1682. (which agrees perfectly well with our Numbers). I conclude the middle of this to have happen'd at *London* at 3^h

The Longitude *of the* Cape Good Hope, *&c. by Dr.* E. Halley. n. 361. p. 992.

‖ *Vid.* Supra V. I. C. VII. S. XXVI.

48′ *P. M.* to which adding $1^{h}\ 46'$ for the Semiduration (this being very certain from the obſerved Continuance of the Eclipſe of 1682.) the End will be found to have been at *London* at $5^{h}\ 34'$. The Ship was therefore in a Meridian 26° to the Eaſtwards of *London:* But ſhe was at that Time 180 Leagues to the Eaſtwards of the *Cape*, which Diſtance in that Latitude, gives eleven Degrees of Longitude; this therefore being deducted from the Longitude of the Ship, leaves juſt 15 *gr.* or one Hour, for the Difference of Meridians between *London* and the *Cape*. So that by this Account, the *Cape* is yet nearer our Meridian than I had formerly plac'd it, and near ſix Degrees nearer than M. *De la Hire* places it in his Tables.

This Eclipſe was attended with all the Circumſtances requiſite to make the Concluſion as certain as the Nature of the Thing will admit of: For the Moon was nearly *in Perigæo*, and the Eclipſe almoſt central; ſo that ſhe emerged out of the Shadow as ſwiftly as poſſible. The Sea was very ſmooth, there having been little Wind for above 30 Hours before; and the Moon was not too high to be well obſerved with a Foreſtaff: Nor were they long at Sea, before they made the Land; for in leſs than five Days, on the tenth of *March*, at Noon, they had paſt Cape *d'Agulhas*, the moſt Southerly Promontory of *Africa*, which then bore from them *North Eaſt*, about ſeven Leagues diſtant. The End of this Eclipſe, though not viſible here, might have been ſeen in *Germany*, both at *Nurenburg*, *Leipſick* and *Berlin*; but we do not hear that it was any where obſerved there: However, our Numbers in this Caſe may be ſecurely relied on.

On this Occaſion, I ſhall inſert an Obſervation or two I procured to be made at the *Cape*, by Mr. *Alexander Brown*, a *Scotch* Gentleman. He carried with him a very good *Braſs Quadrant* of above two Foot Radius, and at the *Dutch* Settlement at *Table Bay*, having rectify'd his *Pendulum Clock* by correſpondent Altitudes, on the *4th* of *Auguſt* 1694. at $5^{h}\ 59'$ *Manè*, the Diſtance of the bright Limb of the Moon from the Right Shoulder of *Orion*, was obſerv'd to be 25° 3′. And the next Morning *Aug.* 5. at $5^{h}\ 21'\ 12''$, the ſame Limb was diſtant from *Procyon* 25° 57′, and at $5^{h}\ 36'\ 48''$ from the *Lucida Arietis* 58° 29′.

It were much to be wiſh'd, that the Moon had, either of theſe Mornings, been obſerv'd at *Greenwich* or *Paris*, or at ſome Place in *Europe* whoſe Longitude from them is well known: But that failing us, I had recourſe to the Period of the Lunar Motions, which is perform'd in 18 Years and ten or eleven Days; after which, the Errors of our Lunar Computations return very nearly the ſame; and I found among my own old Obſervations, one that agreed well with that of the *4th* of *Auguſt*, *viz.* Anno 1676. *July* 23° $13^{h}\ 11'\ 35''$ at *Oxford*, I obſerv'd the Moon to apply to the Star *in medio Collo Tauri*, by *Bayer* mark'd *A.* The Star at that Time was diſtant from the Southern and neareſt Cuſp of the Moon, by the Micrometer 20′ 32″, and at $13^{h}\ 17'\ 15''$, when it ſeem'd to immerge upon the bright

Limb of the Moon, it was diſtant from the Northern Cuſp 23′ 20″; but this is leſs certain, by reaſon of the hazy Air. The Star at that time was in ♉ 28° 56′ with 1° 13′ 20″ *North* Lat. whereby I found, that our Lunar Tables, founded on Sir *Iſaac Newton*'s Theory of her Motion, gave her Place at that Time only two Minutes too ſlow; which Error being allowed on the *4th* of *Auguſt* 1694. the Reſult was, that 5^{h} 59′ at Cape *Bonne Eſperance*, was at *London* 4^{h} 53′; whence the Difference of Longitude 16 ½ Degrees, ſufficiently near what we had before determin'd.

Of the Variation *at* Paraiba, &c. *And the* Longitude *of the* Magellan Straights, &c. *by Dr.* E. Halley. n. 341. p. 165.

IV. The Gentlemen of the *Royal Academy of Sciences* in *France*, have, for ſome Years paſt, apply'd themſelves with much Candour and Diligence, to examine the Chart I publiſh'd in the Year 1701. for ſhewing at one View the Variations of the Magnetical Compaſs, in all thoſe Seas with which the *Engliſh* Navigators are acquainted; and I find, that what I did ſo long ago, has been ſince abundantly verified by the concurrent Reports of the *French* Pilots, who of late have had frequent Opportunities of inquiring into the Truth thereof. So that I am in Hopes, I have laid a ſure Foundation for the future Diſcovery of the Law or Rule by which the ſaid Variations change, in Appearance regularly, all the World over. Of this I have long ſince given my Thoughts, † and as yet I ſee no Cauſe to retract what I there offer for a Reaſon of this Change; but of this we might be more certain, had we a good Collection of Obſervations made in that Ocean, which divides *Aſia* and *America*, and occupies about two Fifths of the whole Circumference of the Globe. This, we hope, may be effectually ſupply'd by the *French*, who may return from *Peru* by the *Eaſt Indies*.

† *Vid.* Supra V. II. C. IV. S. VIII.

In the mean time I cannot omit to take Notice of two Particulars, ſeeming to call in Queſtion the Truth of my aforeſaid Map, in the *Memoirs* of the *Royal Academy of Sciences*.

Of the Variation *at* Paraiba *in* Brazile.

The one is in the *Memoirs* of the Year 1700. concerning the Variation obſerved at *Paraiba* in *Brazile*, about 25 Leagues to the Northwards of *Pernambouc*, by M. *Couplet le fils*, whoſe Words are theſe:

'*May* 20. 1698. Having before carefully drawn a Meridian Line, which I made uſe of for Aſtronomical Obſervations, I obſerved the Declination of the Needle touch'd by the Loadſtone to be 5° 35′. N. W.' And the ſame Obſerver tells us, that he found the Latitude of the Town of *Paraiba* 6° 38′ 18″. Now it happen'd, that I was in the River of *Paraiba*, in *March* 1699. and there fitted and clean'd my Ship; ſo that I had full Opportunity to obſerve the Variation both on Board and on Shore, and found it conſtantly to be above 4 *gr. North Eaſt*; ſo that I am willing to believe this to be an Error of the Preſs, putting N. W. for N. E. or rather of the Memory of M. *Couplet*, who, it ſeems, loſt all his Papers by Shipwreck in his Return. The ſame may be ſaid of the Latitude of *Paraiba*, which, though I did not obſerve myſelf, yet at the Fort of *Cabo Dello*, at the Mouth of the River, and which is about 3 Leagues more Northerly than the Town, I found the Latitude not leſs than 6° 55′ South, and by Conſequence that of the Town more than 7 Degrees.

The other is in a Diſcourſe of M. *de Liſle*, in the *Memoirs* of 1710; where he compares the Variations obſerved in ſome late Voyages, with my Map of the Variations. Among other Things, 'tis there ſaid, that on the Eaſt-ſide of the Iſland St. *Thomas*, under the Equinoctial Line, M. *Bigot de la Canté*, had, in the Beginning of the Year 1708, found the Variation 11½ *gr.* whereas my Chart makes it but 5½ *gr.* I never indeed obſerved myſelf in thoſe Parts; and 'tis from the Accounts of others, and the Analogy of the whole, that in ſuch Caſes I was forc'd to ſupply what was wanting; and 'tis poſſible, that there may be more Variation on that Coaſt than I have allowed. But conſulting my Chart, (which was fitted to the Year 1700,) I find I then make the Variation at the Iſle of St. *Thomas* full 7½ *gr.* and not 5½ *gr.* the which, by the Year 1708, might well riſe to near 9 *gr.* So that the Difference will become very tolerable; whereas an Error of 6 *gr.* ſuch as is here repreſented, would render the Credit of my Chart juſtly ſuſpected.

Of the Longitude *of the* Magellan *Straights.*

But a further Thing I might complain of, is, that in the ſame *Memoir* of M. *de Liſle*, the *Geography* of my Chart is called in Queſtion; and we are told, that I have placed the Entrance of the *Magellan* Straights at leaſt 10 Degrees more Weſterly than I ought to have done: For that the Ship St. *Louis*, in the Year 1708, ſailing from the Mouth of *Rio Gallego*, in about the Latitude of 52 *gr.* South, and not far from Cape *Virgin*, directly for Cape *Bonne Eſperance* (which Courſe perhaps was never run before) had found the Diſtance between the two Lands not more than 1350 Leagues, which, he concludes, is much leſs than my Chart of the Variation makes it. I know not from what Computation M. *de Liſle* has drawn this Conſequence; but I find by my Chart that I have made the Longitude of *Rio Gallego* 75 *gr.* Weſt from *London*, and that of Cape *Bonne Eſperance* 16½ Eaſt from it; that is in all 91½ *gr.* Difference of Longitude. This with the two Latitudes, gives the Diſtance, according to the Rhumb-line, 1364 Leagues; but according to the Arch of a great Circle, no more than 1287 Leagues. So that inſtead of invalidating what I have there laid down, it does abſolutely confirm it, as far as the Authority of one ſingle Ship's Journals can do it.

I do not pretend, that I have had Obſervations made with all the Preciſion requiſite, to lay down inconteſtably the *Magellan* Straights in their true Geographical Site; but it has not been without good Grounds, that I have placed them as I have done. For when Sir *John Narborough*, in the Year 1670, wintered in Port St. *Julian*, on the Coaſt of *Patagonia*, Capt. *John Wood*, then his Lieutenant, and an approved Artiſt in Sea-Affairs, did obſerve the Beginning of an Eclipſe of the Moon, *Sept.* 18. *Stil. vet.* at juſt 8 at Night: And the ſame Beginning was obſerv'd by M. *Hevelius* at *Dantzick*, at 14ʰ 22′; whence

Port St. *Julian* is more Weſterly than *Dantzick* 6ʰ 22′, or than *London* 5ʰ 6, that is 76½ *gr.* Beſides, I have had in my Cuſtody a very curious Journal of Capt. *Strong*, who went into the *South Seas* in queſt of ~~a Plate-wreck, and who diſcover'd the two Iſlands he called *Falkland*'~~s *Iſles*, lying about 120 Leagues to the Eaſtwards of the *Patagon* Coaſt, about the Lat. of 51. This Capt. *Strong* had a quick Paſſage from the Iſland of *Trinidada* (in 20½ South) to the *Magellan* Straights; and in this Journal, which was very well kept, I found, that Cape *Virgin* was, by his Account, 45 Degrees of Longitude more Weſterly than that Iſland, whoſe Longitude I know to be juſt 30 Degrees from *London*; that is in all, 75 *gr.*

From theſe concurrent Teſtimonies, I adventured to fix the Longitude of this Coaſt as I have done; and I can by no Means grant an Error of 10 Degrees to be poſſible in it, though perhaps it may need ſome ſmaller Correction. I will however readily grant, that thoſe that go thither from *Europe*, ſhall find the Land more Eaſterly than is here expreſs'd, by reaſon of a conſtant Current ſetting to the Weſtward near the Equator, where Ships are many times long detained by Calms, whilſt the Stream carries them along with it; which Thing befals all Ships bound to any Part of the Eaſt Coaſt of the *South America*.

V.

The Variation *of the* Compaſs *in the* Atlantic *and* Æthiopic *Oceans*. A.D. 1706. *by Mr.* J. Maxwell, n. 310. p. 2433.

Variation.	Latitude.	Longit. from *London*.
8° 32′ Weſt.	49° 18′ North.	07° 29′ Weſt.
6 42	44 31	13 45
5 30	41 06	15 08
5 04	40 22	14 54
4 22	39 11	15 35
3 30	32 21	15 39
3 35	32 42	15 38
1 20	18 50	20 52
1 14	09 26	17 59
1 10	00 49	18 42
1 00	01 09 South.	18 58
0 16	02 32	19 48
0 00	03 17	20 05
0 40 Eaſt.	03 58	20 27
1 02	05 09	21 39
1 30	06 21	22 08
1 50	08 03	23 15
2 10	09 07	23 35
3 32	12 03	25 03
6 04	18 53	26 30
6 19	19 51	27 02

Variation.	Latitude.	Longit. from *London.*
6° 20′ Eaſt.	21° 26′ South.	28° 14′ Weſt.
6 30	21 48	28 10
7 00	21 58	28 23
6 45	24 45	27 56
6 36	27 11	27 17
5 04	33 53	16 58
0 00	34 21	01 29 30″
1 00 Weſt.	34 15	01 33 Eaſt.
4 16	33 41	06 23
8 46	34 39	13 02
11 56	14 30	16 15 *at the Cape of*
11 30	32 51	13 41 Good Hope.
10 00	30 21	11 46
09 44	29 51	11 44
09 34	29 28	11 31
09 22	28 56	11 05
09 04	27 38	10 01
08 30	26 55	08 45
08 02	25 41	07 22
07 32	24 32	05 43
01 52	16 00	06 30 Weſt *at the Iſle of St.* Helena.

A Mechanical Way to divide *the* Nautical Meridian Line *in* Mercator's *Projection. And the* Relation *of that* Line *to the* Curva Catenaria, *by Mr.* J. Perks. n. 345. p. 331.

VI. The moſt uſeful Projection of the Spheric Surface of Earth, and Sea for Navigation, is that commonly call'd *Mercator's*; tho' it's true Nature and Conſtruction is ſaid to be firſt demonſtrated by Mr. *Wright*, in his *Correction of the Errors in Navigation.* In this Projection the Meridians are all parallel Lines, not divided *equally*, as in the common plain Chart (which is therefore erroneous) but the Minutes and Degrees (or ſtrictly, the *Fluxions of the Meridian)* at every ſeveral Latitude are proportional to their reſpective *Secants.* Or a Degree in the projected Meridian at any Latitude, is to a Degree of Longitude in the Equator, as the *Secant* of the ſame Latitude is to *Radius.*

The Reaſon of which Enlargement of the Elements of Latitude is, to counterbalance the Enlargement of the Degrees of Longitude. For in this Projection, the Meridians being all parallel, a Degree of Longitude at (ſuppoſe) 60 Deg. Lat. is become equal to a Degree in the Equator, whereas it really is (on the Globe's Surface) but *half* as much, the Radius of the Parallel of 60 Deg. (that is its *Coſine*) being but *half* the Radius of the Equator. Therefore to proportion the Degrees of Latitude to thoſe of Longitude, a Degree (or Elemental Particle)

ticle) in the Meridian, is to be as much greater than a Degree (or like Particle) in the Equator, as the Radius of the Equator is greater than the Radius of the Parallel of Latitude, *viz.* its *Coſine.*

Let the Radius CD repreſent half of the Equator, DM an Arc of the Meridian; MS its Sine, CE its Secant; then is CS equal to its *Coſine:* and $CS : CM :: CD\ (= CM) : CE$, that is, as Coſine : to Radius :: ſo is Radius : to Secant. The Coſines being then, in this Projection, ſuppos'd all equal to Radius, or (which comes to the ſame) the Parallels of Latitude being all made equal to the Equator, the Radius of the Globe, at every Point of Latitude, (by the precedent Analogy) is ſuppoſed equal to the Secant of Latitude; and conſequently the Elements (Minutes, *&c.*) of the Meridian muſt be proportional to their reſpective Secants. Fig. 214.

The Way Mr. *Wright* takes for making his Table of *Meridional Parts*, is by a continual Addition of Natural Secants, beginning at 1 Minute, and ſo proceeding to 89 Deg. Dr. *Wallis* (in *Phil. Tranſ.* Nº 176.) finds the Meridional Part belonging to any Latitude by this *Series*, putting S for its Natural Sine, *viz.* $S + \frac{1}{3}S^3 + \frac{1}{5}S^5 + \frac{1}{7}S^7 + \frac{1}{9}S^9$ &c. which gives the *Merid. Part* required. How to find the ſame mechanically by Means of an eaſily conſtructed Curve Line, is what I ſhall now ſhew.

1. Prepare a Rular AB of a convenient Length, in which let Ba be equal to the Radius of the intended Projection. To the Point a as a Center (on the narrower Edge of the Rular) faſten a little Plate-Wheel wb tight to the Rular, and of a Diameter a little more than the Thickneſs of the Rular. Let KR (*Fig.* 214.) repreſent another long Rular, to which AR is a perpendicular Line. Place the Rular AB upon the Line AR, with the Center of the Wheel at A. Then with one Hand holding faſt the Rular KR, with the other Hand ſlide the End B of the Rular AB by the Edge of KR; ſo will the little Wheel wb deſcribe on the Paper a Curve Line ACB, to be continued, as far as is convenient. Fig. 213. Fig. 214.

2. Having drawn the Curve ACB, draw a ſtraight Line KR by the Edge of the Rular KR: which Line is the Meridian to be divided; and alſo an Aſymptote to the Curve ACB.

3. In this Meridian, (accounting R to be the Point of its Interſection with the Equator,) the Point anſwering to any Degree of Latitude is thus found. In the Perpendicular AR, make RG equal to the *Coſine* of Latitude (Radius being AR,) and from G draw GC parallel to KR, and interſecting the Curve in C. With Center C and Radius $CM = AR$, ſtrike an Arc, cutting the Meridian at M; ſo is M the Point deſir'd.

4. In the Curve AC, let c be a Point infinitely near to C, and cm $(= CM)$ a Tangent to the Curve at c, making the little Angle MCm, to which let the Angle RAr be equal. So is $Rr = Md$ (a Perpendicular from M to cm.) Draw CD equal and parallel to AR, interſecting

KR in S. With Center C and Radius CD draw the Arc DM, and its Tangent DE and Secant CE.

5. Becauſe of the like Triangles CDE, Mdm; $CD : CE :: MD : Mm$, that is, as Radius to Secant of the Arc DM, (whoſe Coſine is $CS = GR$,) :: ſo is Md ($= Rr$ a Degree or Particle of the Equator :) to Mm the Fluxion or correſpondent Particle of the Meridian Line RM. Whence, and from what is premiſed concerning the Nature of this Nautical Projection, 'tis evident, that RM is the *meridional Part*, anſwering to the Latitude whoſe Coſine is GR. Or thus; With Center R and Radius AR deſcribe the Quadrant $A\varkappa\alpha$, in which let the Arc $A\varkappa$ be equal to the given Lat. From $\varkappa$ draw $\varkappa C$ parallel to KR, and interſecting the Curve in C, ſo is $C\varkappa$ the Meridional Part deſir'd, being equal to RM, as is eaſy to ſhew.

6. As to the other Properties of this Curve, 'tis evident, from its Conſtruction, that its *Tangent* (as CM) is a *Conſtant Line* every where equal to AR; the Curve being generated by the Motion of the Wheel at the End of the Rular which is its Tangent. And from hence the Curve ACB may, for Diſtinction, be call'd the *Equitangential Curve*.

7. The Fluxion of the Area $ARMC$ is the little Sector or Triangle MCd, which ſame is alſo the Fluxion of the Sector CDM: whence the Areas $ARMC$, CDM are equal, and the whole Area ACB, &c. KMR being infinitely continued, is equal to the Quadrant $AR\alpha$.

8. To find the Radius of Curvature of any Particle, as Cc, from C draw an indefinite Line CT perpendicular to CM, (on the Concave ſide of the Curve) and from c another Line perpendicular to cm, which Lines, (becauſe of the Inclination of CM to cm) will ſomewhere meet as at T, making an Angle $CTc = MCm$. Theſe Angles being equal, their Radii are proportional to their Arcs: therefore, $Md : Cc :: MC : CT$. But $Cc = dm$ (becauſe of $CM = cm$) ſo that $Md : dm$ ($:: CD : DE$) $:: CM : CT$. But $CD = CM$, therefore $CT = DE =$ Tangent of the Arc DM.

9. So that ſuppoſing ATt a Curve Line, in which are all the Centers of Curvature of the Particles of ACB, any point as T being found as before, the Length AT (by the Nature of *Evolution of Curves*,) is every where equal to the *Tangent* of its correſpondent circular Arc DM. The Point T is alſo found by making MT perpendicular to RM, and equal to the Secant CE: for ſo is the Angle $CMT = MCD$; and the Triangle MCT equal to the Triangle CDE.

10. Let AHb be an Equilateral Hyperbola, whoſe Semiaxis is AR and Center R. In the Meridian let RP be equal to the Tangent DE. Join AP, and draw $PH = AP$ and parallel to AR. Compleat the Parallelogram $HNRP$, ſo will the Point H be in the Hyperbola, and its Ordinate HN ($= RP = DE = CT$) be equal to the Curve ATt. From whence, and from *Prop.* 3. *Coroll.* 2. of Dr. *Gregory*'s *Catenaria* (*Phil. Tranſ.* N° 231.†) it appears, that the Curve ATt is that called

† *Vid.* Supra. V. I. C. I. S. XIII.

the *Catenaria* or *Funicularia*, *viz.* the Curve, into whoſe Figure a *ſlack Cord or Chain* naturally diſpoſes its ſelf by the Gravity of its Particles.

“ 11. Hence we have another Property of the *Catenaria* not hitherto
“ taken Notice of (that I know of) *viz.* that ſuppoſing *AR* (= *a*, the
“ conſtant Line in Dr. *Gregory*) equal to the *Radius* of the Nautical
“ Projection, and *RN* the Secant of a given Latitude, then is *NT* the
“ *Catenaria*'s Ordinate at *N*, equal to *RM* the Meridional Part anſwer-
“ ing to the Latitude, whoſe Secant is *RN*.

12. That *TA* is the *Catenaria* is alſo demonſtrable from Dr. *Gregory*'s firſt *Prop.* Let *Tu* be the Fluxion of the Ordinate *NT*: and *tu* (= *Nn*) the Fluxion of the Axe *AN*. Then becauſe of like Triangles *TCM*, *Tut*, *CM* : *CT* (= *TA*) : : *Tu* : *ut*, that is, as *CM* a conſtant Line is to *TA* the Curve : : ſo is the Fluxion of the Ordinate to that of the Axe $(\dot y : \dot x)$ according to *Prop.* 1. *Catenariæ*.

13. From the Premiſſes the Conſtruction and ſeveral Properties of the *Catenaria* are eaſible deducible; one or two of which I'll ſet down.

The Area *ATMR* is equal to *AOPR* a Rectangle contained by Radius *AR*, and *RP* the Tangent anſwering to Secant *HP* = *TM*. For becauſe of the like Triangles *CMm*, *CEe*; *CM* : *CE* : : *Mm* : *Ee*, (that is, putting *r*, *s*, *t*, *m* for Radius, Secant, Tangent and Meridional Part *RM*) $r : s :: \dot m : \dot t$ whence $r\dot t = s\dot m$, and all the $r\dot t$ = all the $s\dot m$, that is *AOPR* = *ATMR*, which agrees with Dr. *Gregory*'s *Cor.* 5. of *Prop.* 7.

14. Suppoſing the former Conſtruction, let be added the Line *RH*, including the *Hyperbolic Sector ARH*. I ſay the ſame Sector is equal to half the Rectangle *ARMQ* contained by Radius *AR* and the Meridional Part *RM*, $(= \frac{1}{2} rm)$ For the Sector *ARH* = Triangle *RNH* wanting the Semiſegment *ANH*, The Fluxion of the Triangle *RNH* is $\frac{s\dot t + t\dot s}{2}$. The Fluxion of *ANH* is $t\dot s$. So the Fluxion of the Sector *ARH* is $\frac{s\dot t + t\dot s}{2} - t\dot s = \frac{s\dot t - t\dot s}{2}$. 'Tis found before (*Sect.* 13.) that $r : s\ (s : \frac{ss}{r}) :: \dot m : \dot t$; whence $s\dot t = \frac{ss}{r}\dot m$. And becauſe of the like Triangles *CDE*, *Efe*, *CD* : *DE* : : *Ef* : *fe*. But $Ef = Mm = \dot m$, becauſe both *Ef* and *Mm* are to *Md* in the ſame Reaſon, *viz.* as *s* to *r*; therefore $r : t\ (t : \frac{tt}{r} :: \dot m : \dot s$: whence $t\dot s = \frac{tt}{r}\dot m$, and $\frac{s\dot t - t\dot s}{2} = \frac{ss - tt}{2r}\dot m = \frac{rr}{2r}\dot m = \frac{1}{2} r\dot m$, = the Fluxion of the hyperbolic

Sector ARH, whoſe flowing Quantity is therefore equal to $\frac{1}{2} rm = \frac{1}{2}$ $ARMQ$. *Q. E. D.*

15. This ſhews another Property of the *Catenaria, viz.* that it ſquares the Hyperbola; for RM is equal to NT the Ordinate of the *Catenaria.*

Fig. 215. 16. Let AR be Radius, ACB the Equitangential Curve; MRN its Aſymptote, in which let M, N, be any two Points equally diſtant from R. Upon M draw ML parallel to AR and equal to the *Difference* of the Secant and Tangent of that Latitude, whoſe Meridional Part is RM. (by *Sect.* 3, 4.) Upon N draw NO parallel to AR, and equal to the *Sum* of the foreſaid Secant and Tangent. Do thus from as many Points in the Aſymptote, as is convenient, and a Curve drawn equably through the Points L—A—O, &c. will be a *Logarithmic Curve*, whoſe *Subtangent* (being conſtant) is equal to Radius AR.

17. Let no be an Ordinate infinitely near and parallel to NO. $Op = Nn$ the Fluxion of the Aſymptote; OT the Tangent, and TN the Subtangent to the Logarith. Curve in O. Then $op : pO :: ON : NT$. But $ON = s + t$, therefore $op = s + t$. $pO = m$ (the Fluxion of the Meridian or Aſymptote.) So the Analogy is $s + t : m :: s + t : NT$. By *Sect.* 13, 14. $s : m :: t : r$. alſo. $t : m :: s : r$. and thence $s + t : m :: t + s : r$. wherefore is NT (the Subtangent to LAO) equal to Radius AR a conſtant Line, and conſequently the Curve LAO is the Logarithmic Curve, and its Subtangent known.

18. The ſame Demonſtration ſerves for LM (any Ordinate on the other Side of AR) only changing the Sine $+$ into $-$; and then it agrees with Mr. *James Gregory*'s *Prop.* 3. *pag.* 17. of his *Exercitations*; viz. *That the Nautical Meridian is a Scale of Logarithms of the Differences whereby the Secants of Latitude exceed their reſpective Tangents, Radius being Unity.* So here RM is the Logarithm of ML, the Difference of the Secant and Tangent of the Latitude, whoſe Meridional Part is RM.

19. Suppoſing the precedent Conſtruction, if through any Point C of the Curve ACB be drawn a right Line GCW parallel to MR, terminated with the Logarithmic Curve in W and the Radius AR in G: I ſay, that the ſame right Line WG is equal to the intercepted Part of the Curve Line AC.

20. Let wg be a Line infinitely near and parallel to WG, and terminated by the ſame Lines; and CS, $W\sigma$, perpendicular to the Meridian; CS interſecting wg in z, and $W\sigma$ in y. Let CM be a Tangent to AC in C; $W\tau$ a Tangent to AW in W; ſo is $CM = \sigma\tau$. Becauſe of like Triangles Czc, CSM; and Wyw, $W\sigma\tau$; $CS : CM :: Cz : Cc$: alſo $W\sigma : \sigma\tau :: Wy : yw$. But $W\sigma = CS$; $\sigma\tau = CM$; $Cz = Wy$; therefore is yw the Fluxion of GW, equal to Cc, the Fluxion of the Curve AC. Conſequently $GW = AC$ *q. e. d.*

21. It may be noted, that this Equitangential Curve gives the Quadrature of a Figure of Tangents ſtanding perpendicular on their Radius. In *Fig.* 214. let $A\gamma\Gamma$ be a Curve, whoſe Ordinates as $g\gamma$, $G\Gamma$, are equal to the Tangents of their reſpective intercept Arcs Ak, $A\kappa$. Let ΓG be produced to touch the Curve AC in C: then is the Area $A\Gamma G$ equal to the Rectangle contained by Radius AR and GC the produced Part of the Ordinate; or $A\Gamma G = AR \times GC$. The Demonſtration of which, and of the following *Section*, I for Brevity omit.

22. If we ſuppoſe the Figure ACB, &c. KR, (*Fig.* 214.) infinitely continued, to be turned about its Aſymptote RK as an Axe, the Solid ſo generated will be equal to a rectangled Cone, whoſe Altitude is equal to AR; and its Curve Surface will be equal to half the Surface of a Globe whoſe Radius is AR. So that if the Curve be continued *both ways* infinitely (as its Nature requires) the whole Surface will be equal to that of a Globe of the ſame Radius AR.

Fig. 213.

Fig. 216.

The Deſcription of the Rular and Wheel, *Fig.* 213. is ſufficient for the Demonſtration of the Properties of the Curve: But in order to an actual Conſtruction for Uſe, I have added *Fig.* 216. where AB is a Braſs Rular; wb the little Wheel, which muſt be made to move freely and tight upon its Axe (light a Watch-wheel) the Axe being exactly perpendicularly to the Edge of the Rular. s repreſents a little Screw-pin to ſet at ſeveral Diſtances for different Radii, and its other End is to ſlide by the Edge of the other fix'd Rular. p is a Stud for the convenient holding of the Rular in its Motion.

N. B. *Moſt of the Properties of this* Curve *by the Name of* la Tractrice, *are to be found in a* Memoire *of M.* Bomie *among thoſe of the* Royal Academy *of* Sciences *for the Year* 1712, *but not publiſhed till* 1715: *Whereas this Paper of Mr.* Perks *was produced before the* Royal Society, *in* May 1714, *as appears by their* Journal.

VII. 1.] I have lately thought of a new Inſtrument for drawing a Meridian Line; it is eaſy in its Uſe, and ſufficiently exact.

A New Way of drawing a Meridian Line, *by Mr.* S. Gray. n. 268. p. 763.

Take the Gnomon of an horizontal Dial for the Latitude of the Place, and to the *Hypothenuſa* fix two Sights, whoſe Centers may be parallel to the ſame: let the Eye-ſight be a ſmall Hole; but the other's Diameter muſt be equal to the Tangent of the double Diſtance of the *North-Star* from the Pole, (the Diſtance of the Sights being made *Radius.*) Let the Stile be riveted to the End of a ſtraight Ruler: When you would make uſe of it, lay the Rular on an horizontal Plane, ſo that the End to which the Stile is fix'd may over-hang; then look through the Eye-ſight, moving the Inſtrument, till you ſee the North-Star appear to touch the Circumference of the Hole in the other Sight, on the ſame Hand with the Girdle of *Caſſiopeia*; or on the oppoſite Side to that, whereon the Star in the Great Bear's Rump is, at that

Time: then draw a Line by the Edge of the Ruler; and it will be a true Meridian Line, as it is eaſy to demonſtrate.

I do not hear that any of the Occultations of *Aldebaran* by the Moon were obſerv'd laſt Year: I expected ſeveral, but was always hinder'd by the Weather from obſerving any.

—*on the* ſame *by the* ſame. n. 270. p. 815.

2.] I have ſent ſome farther Thoughts upon the Inſtrument for drawing a Meridian Line, and have improved it ſo far, that no other *Star* will be made uſe of than the *Polar* one to obtain the Hour and Minute of the Day or Night.

Let there be taken a Teleſcope of about 16 Foot, or longer if you pleaſe; in the Plane of its Focus place a Ring of Braſs at right Angles to the Axis of the Glaſs, the Diameter of the inward Circle equal to the double Tangent of the Pole-Star's Diſtance from the Pole; the focal Length of the Object Glaſs being made Radius, as was ſaid in the Deſcription of the Meridian Inſtrument; let the Ring be divided into 24 Hours, with their Minutes number'd from the Right-hand towards the Left, as in our common Nocturnals; the Eye Glaſs muſt be equal in its Diameter to the Horary Ring: but this perhaps will be thought too chargeable, eſpecially for ſuch large Teleſcopes as I am ſpeaking of, which has made me think of this Contrivance: The Eye Glaſs muſt lie in a broad Index towards one End, this is to turn on a Center Pin, that lies in the Center of the Glaſs, and conſequently over the Center of the Horary Ring, from which it muſt be equal to the Diſtance of the Focus of the Eye Glaſs; then let the Tube be elevated to the Height of the Pole, and directed to the Pole-Star, till by turning the Index through the Eye Glaſs, you perceive the *Star* to touch the Horary Ring on that Side the Star in the *Great Bear's Rump* lies, or on the oppoſite to that in the Hip of *Caſſiopeia*; but on the contrary, had not the Glaſs inverted the Object, then bring one of the twelves to be in a Perpendicular to the other by a Plumb-line; ſo will the Star ſtand at its Horary Diſtance from the Meridian; or if the Latitude of the Place be unknown by the Right Aſcenſion of the Sun and Star, the Time of its coming to the Meridian will be eaſily obtained; and then the Hour of the Night found, will as eaſily give the Star's Horary Diſtance from the Meridian; then elevate the Tube towards the Star, bringing the Meridian, or 12 and 12 into the Plane of the Perpendicular; turn the Glaſs about, till you ſee the Pole-Star ſtand at its Horary Diſtance from the Meridian; ſo will the Inſtrument when fixed, ſhew the Horary Diſtance throughout the whole Day, or as long as it remains in this Poſition, by the apparent Motion of the Star in the Ring. The beſt Time to fix the Inſtrument will be, when this, or any of the other two Stars above-mentioned, are about 6 Hours from the Meridian. It is to be obſerv'd, that the Latitude of the Place is now given with the utmoſt Preciſeneſs: for the Axis of the Glaſs lies now in the Axis of the World; and if one of the Sides of the Tube be parallel thereto, as it ought to be at the upper End, hang a Line and Plummet from the Point of the Suſpenſion; find another Point equal in Diſtance to the Length of the Line, or a Knot towards the lower End, the Diſtance from this Knot to the former Point will be but the Chord of the Latitude; and if from the ſame Edge of the Index, another Line and Plummet be hung towards the lower End of the Tube, theſe two Lines, when at reſt, will be in the Plane of the Meridian.

This Inſtrument may be made to ſhew the Hour with as much Facility as a Clock or Sun-dial, if the Horary Ring be made to move within a larger fixed one; and the outward Circle of the former be divided into the Days of the Month, reſpect being had to the Right-Aſcenſion of the Sun and Star: Then by bringing the two oppoſite Points in the fixed Circle to the Perpendicular, which is done at the fixing the Inſtrument, move the Circle till the Day of the Month come to any of theſe, and the Ring is rectified for that Day; and if the Air be clear, you will ſee the Star ſtand at the true Time of the Day or Night.

It may be objected, that in a few Years, by the Annual Increaſe of its Declination, the Pole-Star will, by moving in a leſſer Circle, be brought too far from the Edge of the Ring, that the exact Hour and Minute cannot well be diſtinguiſh'd: but this Inconveniency, when it is one, may be eaſily remedied ſeveral Ways; either by making a leſſer Ring, or by extending a fine Thread of Silk croſs the Ring, till it cuts the Star, and at the ſame Time it gives the Hour; or, which will yet make this Inſtrument commodious for other Purpoſes, there may be made an Index to move on the Center of the Hour-wheel, which being brought to cut the Star with the Edge that proceeds from the Center, it will at the ſame Time cut the Hour: And now we need not be ſollicitous about the exact Diameter of the Ring, provided it do but a little exceed the Diſtance of the Pole-Star from the Pole, the focal Length of the Glaſs being made Radius.

Mr. *Flamſteed* has diſcovered, that there is a Parallaxis of the Earth's Annual Orbit at the Pole-Star of about 40 or 45 Seconds; whereby the Diameter of the Star's Parallel is greater in *June* than in *December*, by about 1 Min. 2 Seconds; which he has evinced from ſeven Years ſucceſſive Obſervations, whereby the Earth's Motion is indubitably demonſtrated, as appears from his Letter to Dr. *Wallis* on that Subject.

Now if on the Edge of this Index there be drawn a Scale of Degrees, Minutes and Seconds, to the Radius of the Glaſs, we ſhall not only have a very accurate Inſtrument for the Hour, but be furniſhed with one, whereby we ſhall ſee the Truth of the Earth's Motion confirmed by the Acceſs and Receſs of our Star towards and from the Pole, according to the Earth's Place in the Ecliptick, as that learned Perſon has diſcovered; and that not only when the Star tranſits the

Meridian, but in clear Air at any Time of the Day; one ſhall likewiſe obſerve that Annual Increaſe of the Pole-Star's Declination, cauſed by the Preceſſion of the Equinox.

My own Obſervations aſſure me, that the Pole-Star may be ſeen in the Day time with a Teleſcope of 16 Foot; for with one of this Length I ſaw that Star on the 26*th* of *April* 1701, from 4 o'Clock in the Morning till 7, and could have ſeen it longer, had not Clouds interpoſed; and again the firſt of *May*, I did not look for the Star, till the Sun had been up more than half an Hour, *viz.* at 5 in the Morning, yet I ſoon found it, and ſaw it afterwards as oft as I pleaſed, till half an Hour after 9 the ſame Morning; ſo that I doubt not, this Star may be ſeen in a clear Day throughout the whole Year.

The Declination of the Pole-Star for the Year 1700, is 87° 42′ 51″, as I find it by *Ricciolus*'s Catalogue of fixed Stars, in the Appendix to Sir *Edward Sherbourn*'s Sphere of *Manilius*, *&c.* Hence its Diſtance from the Pole at this Time may be aſſumed 2° 17′. the focal Length of my Object Glaſs is 15 Foot 6 Inches, ſo that the Diameter of the Ring will be 14 Inches, and 84 hundredth Parts of an Inch, which is the natural Tangent of the former Arch 2° 17′ doubled; a Circle large enough to be divided into Minutes and Halves, which will be ſo magnified by the Eye-Glaſs, that it will be eaſy to diſtinguiſh the Time to a few Seconds.

It is true, there is ſome Difficulty in fixing up this Inſtrument; and when it is ſo, to keep it from varying from its due Poſition; but yet it is not inſuperable: But for ſmall Inſtruments, of about 2 or 3 Foot long, there cannot be a more accurate, eaſy, and expeditious Way than this for drawing a Meridian Line. But whether the many Benefits that may accrue to Aſtronomy, do not make the larger one worth the Charge and Trouble of compleating it, I leave to the Conſideration of the Learned.

An Inſtrument *for finding the* Meridian. *By Mr.* W. Derham. n. 291. p. 1578.

VIII. Among all the Ways contriv'd for finding the Meridian of any Place, the moſt commodious, I think, is an Inſtrument of Sir *Chr. Wren*'s, or two of Mr. *Gray*'s, or one publiſh'd in the Appendix of a Book call'd the *Artificial Clockmaker*.

Sir *C. Wren*'s Contrivance, I am informed, is thus: At one End of a Rular, erect a Sight, to ſee the Pole-Star, *&c.* through. At the other End ſet up two Circles of ſmall Wire, one within the other; the Diameter of the innermoſt, equal to the doubled Tangent of the Diſtance of the Pole-ſtar from the Pole, the Diſtance of the Sight being Radius; and the Diameter of the outermoſt Circle, equal to the double Tangent of the Diſtance of the next Star to the Pole-Star, from the Pole. Your Inſtrument thus prepared, if you look thro' the Sight, and bring the two Circles to the two Stars, whoſe Diſtances from the Pole they repreſent; a Line paſſing through a Sight and Center of the Circles, is the Elevation of the Pole: and two Plumb-lines hung up, one over the

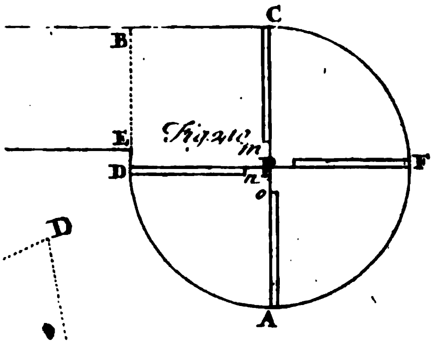


Fig. 211

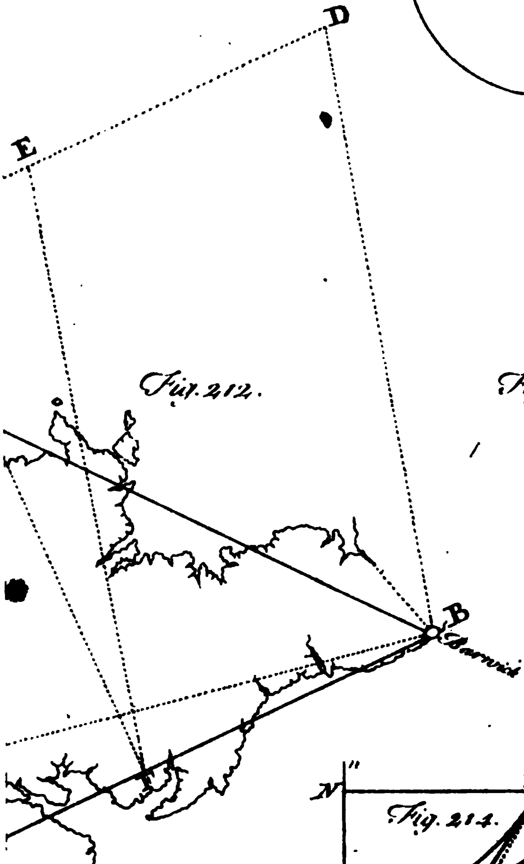


Fig. 212

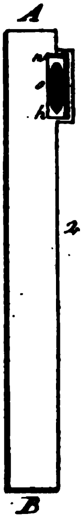


Fig. 213

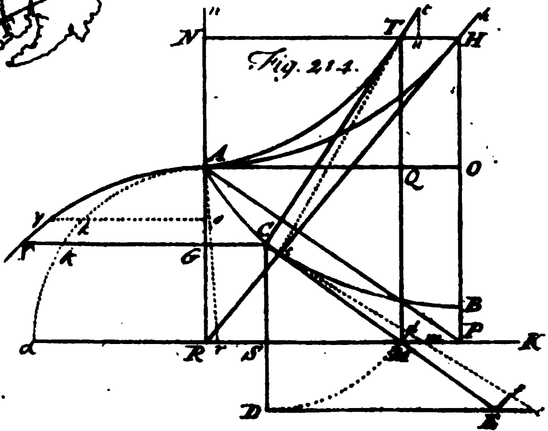


Fig. 214

J. Harris. Sculp.

the Sight, the other over the Center of the two Circles, will exactly lie in the Meridian of the Place.

Mr. *Gray*'s Contrivances being printed, I need not give any Deſcription of them.

The laſt Inſtrument is what I have made uſe of for ſeveral Years, and I would recommend it, upon my own Experience, for a very nice Way to find the Meridian of any Place, and to ſee the *Tranſits* of the Celeſtial Bodies over it, whether Northward or Southward.

The Inſtrument is thus made of Wood, or rather Iron, or Braſs, to endure the Weather, without ſwelling or contracting, *viz.* Prepare a ſmall flat Iron Bar, *C, C,* at each End of which rivet on two upright Sights, to turn ſtiffly, at the Joints *I, I.* Let one of the Sights *c, d,* have a Perforation big enough to ſee the *Pole-Star* through it; the other Sight *a, b,* a very ſmall Perforation, to ſee the *Sun* through. Juſt behind the Joints fix two upright Arms *C, D,* and *C D,* but to bend off, ſo as to be out of the Way of the Sights, when you look through them. Theſe Arms ought to be long enough for the Plumb-lines to reach the Polar-Star, on the one Side; and the Sun at his greateſt Height, on the other Side, when you look through either of the Sights. The Plumb-lines therefore are Tangents to their oppoſite Sights, and their Lengths may be found by a Table of natural Tangents, and making the Diſtance of the two Sights Radius. Thus in the Latitude of *London*, if the Inſtrument be two Feet from Sight to Sight, the Southern Plumb-line hath need to be near four Feet, and the Northern Plumb-line near two Feet ten Inches. On the Tops of theſe two Arms, place two ſmall croſs Pieces *D E* and *D E,* to turn with a Point at *D,* which croſs Pieces are to hold the Plumb-lines *E F* and *E F* and to turn off and on, ſo as to bring the Plumb-lines to the Sights exactly. Place this Inſtrument on a Pedeſtal *H* to turn round on it ſtiffly at the Pin *G.*

Your Inſtrument being thus prepared, the Way to *Set and Uſe it* is thus; plant it in a convenient Place, where the Polar-Star may be ſeen by Night, and the Sun by Day. When that Star is on the Meridian, is the Time to ſet this Inſtrument, which is thus to be done, *viz.* Through the Sight with the large Hole *c, d,* look at the Pole-Star, and turn the whole Inſtrument about, until you ſee the oppoſite Plumb-line nicely to interſect the Pole-ſtar. Or when you have brought the Plumb-line near the Star, you may more eaſily bring the Plumb-line to interſect, by moving the Sight *c, d,* backward or forward, at the Joint I, inſtead of the moving the whole Inſtrument. And that you may more eaſily ſee the Pole-Star through the Sight, let the Plumb-line be a very fine Cats-gut String or Horſe-hair, *&c.* And if it be white, or ſome ſuch light Colour, it will be the better ſeen, with the Help of a Candle ſhining on it by Night, when it is neceſſary.

The Sight *c, d,* and oppoſite Plumb-line being thus ſet in a direct Line with the Polar-Star on the Meridian, it is manifeſt, that the Inſtrument lieth exactly in the Meridian, ſo as to ſee any Star on the Meridian to the North. And that you may ſee the ſame Southerly; the next Day, or when you pleaſe, you may hang up the Plumb-line E, F, upon the Southern Arm *C*, *D*, ſo as that the Plumb-line may exactly interſect the Perforation *c*, *d*. This may eaſily be done by moving the top Joint, with the Plumb-line on its Croſs-piece backward and forward, till the Plumb-line hangeth to your Mind. If the Sight with the leſſer Perforation *a*, *b*, be not exactly under the Northern Plumb-line, it muſt be brought to be ſo, by turning the Sight, by Help of its Joint at I; and then all the Inſtrument is ſet right, ſo as to ſee the Sun, Moon or Stars, come on the Meridian towards the South.

But to ſee the Sun tranſit the Meridian, it is neceſſary to guard the Eye, with a colour'd Glaſs, or a Glaſs darkened with the Smoak of a Lamp or Candle.

A Glaſs *to look through upon the* Sun.

Chuſe two Pieces of Glaſs cut into the ſame Size and Figure; but take care they do not refract vitiouſly; which may be known by moving the Glaſs before the Eye. If the Objects you look on ſeem to dance about, the Glaſſes are falſe and refract; but true if all ſeems ſteady. Smoak one of theſe Glaſſes over the Flame of a Lamp or Candle, until it be obſcured enough to take off the Sun-rays ſufficiently, but not ſo as to darken it too much. This may be ſeen by looking upon the Sun with it, or upon the Candle. One of the Glaſſes being thus darkened, lodge them both together, and faſten them in a little Caſe fit for the Purpoſe, with the ſmoaked Side innermoſt, and an edging of Card between, to keep the Glaſſes aſunder, ſo as that the Soot may not be rubb'd off, or diſordered.

'Tis good to have two Glaſſes thus prepared, one for a ſtrong Sun; the other leſs darkened, for the Sun behind a thin Cloud, Miſt, or, *&c.*

With one of theſe Glaſſes held behind, or before the Sight *a*, *b*, you may plainly ſee the Sun paſs.

— the ſame Inſtrument varied.

Fig. 218.

Inſtead of an intire Inſtrument, prepare only two Sights (as in *Fig.* 218.) with Perforations as before. Let theſe Sights be nailed or ſcrewed down, upon the Tops of two Stakes at *I*, *I*, ſo as to turn ſtiffly upon them. The Plumb-lines (one at leaſt) may be hung up at the End of an Houſe (as at *K*, *Fig.* 218.) or on the Bough of a Tree (if the Wind would not ſhake it) or any where you ſee fit: And the Sights muſt be ſtuck up, ſo as to bring the Pole-Star to interſect, and all be performed, as hath been before directed.

This, although in a Manner the ſame with the Inſtrument before, yet is more convenient in ſome Reſpects. Chiefly becauſe the Plumb-lines may be made longer, and the Sights ſet farther aſunder, than in the Inſtrument before can conveniently be done; which is ſome, altho' no great Advantage for ſeeing the Tranſits. Alſo, theſe Sights may be made ſo light, as to be eaſily carried about; or they may be eaſily made, or imitated in any Place where-ever you come.

To know when the Polar-Star *comes on the* Meridian.

To know when the *Polar-Star* comes on the *Meridian*, the Way is this; ſubtract the *Right Aſcenſion* of the *Sun* from the *Right Aſcenſion* of the *Pole-Star*, the *Remainder* giveth the Degrees, Minutes and Seconds when the Pole-Star tranſits the Meridian above the Pole. Divide theſe Degrees by 15, it gives the Hours; and every Degree under 15 multiplied by 4, gives the Minutes; and every Minute multiplied by 4, gives the Seconds, of apparent Time of the Pole-Star's Southing. I ſcarce need ſay, that it comes under the Pole at 12 Hours Diſtance, only making ſome ſmall Allowance for the Alteration of the Sun's *Right Aſcenſion* in that 12 Hours Time.

But you may ſhorten your Labour, by uſing Tables of the Sun's R. Aſc. in *Time*, inſtead of his R. Aſc. in *Degrees*, &c.

If the Sun's R. Aſc. exceedeth the Pole-Star's, add 360 Degrees, or 24 Hours, and then ſubtract.

The R. Aſc. of the Pole-Star is determin'd by Mr. *Flamſteed* to be $0^h\ 33'\ 4''$ of *Time*, Anno 1690, and the Increaſe of its R. Aſc. in 10 Years $1'\ 16''$ of *Time*. Therefore this preſent Year 1703, the R. Aſc. of the Pole-Star is $0^h\ 35'\ 22''$ of *Time*.

Or you may ſee, when the Pole-Star cometh to the Meridian, by hanging up a Plumb-line, and obſerving when the *Thill Horſe* in *Charles*'s *Wain* called *Alioth*, comes near the Line, together with the Pole-Star, on one ſide the Pole; or the bright Star of the Third Magnitude in *Caſſiopeia*'s *Thigh* on the other ſide, as is repreſented in *Fig*. 219.

Fig. 219.

The foregoing Inſtruments may be ſet by any other Star, as well as the Pole-Star. But the Pole-Star in our Northern Hemiſphere, is moſt convenient, becauſe it maketh but a ſmall Circle round the Pole, and therefore moves ſlower, and conſequently is longer in tranſiting the Meridian. And therefore a ſmall Error in Calculation, or a little Expence of Time in ſetting the Inſtrument, may be admitted.

The Uſes *of theſe Inſtruments.*

The Uſes of theſe Inſtruments are, 1. You may ſee with all imaginable Exactneſs, when it is *Noon*, even to 1, 2, or at moſt 3 Seconds of Time. For you may ſee, when the very Limb of the Sun toucheth the Meridian, and whilſt all his Diſk is paſſing it. So that by much it exceeds all Sun-Dials: ſo far that if you once uſe this Inſtrument, you will be ready to lay aſide all Sun-Dials; the beſt of which (unleſs we except Mr. *Molineux*'s) can never ſhew the Time to one or many Seconds.

But beſides all this, another vaſt Conveniency is, That it will *fit moſt Latitudes*. So that there is no Need of having a ſtrict Regard to the Elevation of the Pole, nor any Danger of Error in making and ſetting, as is in moſt other Inſtruments, but all is with Eaſe and Certainty performed. Therefore,

2*dly*, Into whatſoever Place you come, you may eaſily ſee the Errors of the Sun-Dials there, and which go trueſt, and which falſe.

3*dly*, As the Sun, ſo alſo the fix'd Stars may be ſeen to tranſit the Meridian, whereby the *Hour of the Night* may as exactly be known, as of the Day by the Sun, knowing the R. Aſc. of the Star that tranſits. For (as before for the Pole-Star) ſubtract the R. Aſc. of the Sun from the R. Aſc. of the Star, the Remainder converted into Time, is the Time of that Star's Culmination or Southing. And if 12 Hours be added or ſubtracted (making due Allowance for the Alteration of the Sun's R. Aſc. in that Time) it ſheweth the exact Time of that Star's coming to the Meridian Northward.

4thly, The Hour of the Day and Night being thus to 1, 2 or 3 Seconds, diſcoverable by the aforeſaid Inſtruments, I doubt not, but that they may be uſeful in finding the exact *Differences of Meridians*, either by the *Eclipſes of Jupiter*'s *Satellites*, or the *Occultation* of the *Fix'd Stars* by the *Moon*.

I do not pretend, that theſe Inſtruments are any otherwiſe uſeful in finding the *Longitude*, than by ſhewing the exact Time of the Day or Night; which is one Thing abſolutely neceſſary in this Matter. Neither indeed will they ſerve without a well adjuſted Pendulum-Watch or Pocket-Watch, that will keep Time exactly from one Obſervation by the Meridian-Inſtrument to another. Nor indeed are they uſeful on Shipboard, but only on Land, where they remain fix'd. But on Head-Land, or any where on Shore, they may be uſeful to the Seaman: And indeed (until better Diſcoveries are made) theſe Meridian-Inſtruments may be Uſe, where-ever long Teleſcopes can be of Uſe, for ſeeing the *Appulſes* of the *Moon* to the *Fix'd Stars*, or the Eclipſes of *Jupiter*'s *Satellites*; which is only on Land: Unleſs (which I have thought feaſible) a convenient ſtanding for a Man, a Teleſcope might be hung penduloully in a Ship, which (eſpecially in a calm Sea) may be as little ſubject to Diſturbance, as the Pendulums of Watches are, which will retain their Motion at Sea.

5thly, You may with all Exactneſs continue a Meridian-Line for many Miles, by looking through either Sight, and ſeeing what Objects are interſected by the Plumb-Lines.

Of a Meridian Line *drawn thro'* France, &c. *Communicated by Mr.* Geoffroy, n. 278. p. 1097.

IX. Monſieur *Caſſini* open'd the *Aſſembly* (of the *Academy Royal of Sciences*, Nov. 12. 1701.) with a Diſcourſe containing the Obſervations he had made in his laſt Voyage, with a Deſign to determine the Paſſage of a *Meridian-Line* (taken from a Point in the *Obſervatory* at *Paris*) from one End of *France* to the other. In the firſt Part of this Diſcourſe, he went back to the moſt ancient Aſtronomers, and recounted their Opinions of the Spheric Figure of the Earth, and their Methods to know its Dimenſion; and then proceeded to thoſe of the Moderns. And in the laſt Place, he related the Method of the late Monſieur *Picard*, of the *Academy Royal*, as the moſt exact. Then he ſpoke of his own Obſervations on the ſame Subject, of the Uſe he had made of the *Satellites* of *Jupiter*, more fit for this than the Eclipſes of the Moon, in that they are more frequent; and ſaid that his Obſervations had been confirmed by the like made in *China*. He ſhewed the Method he took to determine

mine the Paſſage of the *Meridian* taken from a Point in the Obſervatory at *Paris*. By the Means of Triangles, which he made through the whole Courſe of his Journey, and very exact Calculations, he determined the Place of this Meridian, and marked all the conſiderable Places through which it paſſed, from *Paris* to the higheſt Mountains of the *Pyreneans*, which ſeparate *Rouſſillon* from *Catalonia*; among theſe Mountains he obſerved one of a prodigious Height, it being 1440 Toiſes high. But the moſt extraordinary Obſervation was that of the Inequality of the Degrees of the Meridian on the Earth; which is ſuch, that Monſieur *Caſſini* found that going Southward one Degree ſurpaſſed another an 800*th* Part, which may give great Reaſon to doubt of the exact Roundneſs of the Earth. Upon this Occaſion he reported two different Opinions, the one of Monſieur *Huygens* and *Newton*, the other of a Mathematician of *Straſburg* named *Eiſenſchmidius*. The two former hold, that the Earth is flatted towards the Poles, ſo that it is ſomething of the Shape of an *Holland* Cheeſe: Which they both conclude by Phyſical and Algebraical Deductions, from an Obſervation made at *Cape Verd*; that the Pendulums, though of the ſame Length, make their Vibrations there much ſlower than in the Northern Countries. The other Mathematician holds, that the Figure of the Earth is Elliptique, ſo that it is ſtretch'd out towards the Poles, and has the Form of an Egg. M. *Caſſini* left the Queſtion undecided. The Cities through which he obſerv'd the *Meridian* of *Paris* to paſs, are *Dunkirk*, *Amiens*, *Aubigny*, *Bourges*, *Aurillac*, *Rodez*, *Alby*, and *Carcaſſione*.

X. *A Paper Omitted.*

Guilielmi Muſgrave Regiæ Societatis Socii de *Britanniâ* quondam *Pene-Inſulâ*, Diſſertatio. n.352.p.589.

CHAP. VII.

MUSIC.

The Theory of Muſic *reduced to* Arithmetical *and* Geometrical Proportions, *by Mr.* T. Salmon. n. 302. p. 2072.

I. HAving made the Trial of a Muſical Experiment before the *Society*, I ſhall give a farther Account of it; that the *Theory* of *Muſic*, which is but little known in this Age, and the *Practice* of it which is arriv'd to a very great Excellency, may be fixed upon the ſure Foundations of *Mathematical* Certainty.

The Propoſitions, upon which the Experiment was admitted, were; That Muſic conſiſted in *Proportions*, and the more exact the Proportions, the better the Muſic: That the Proportions offer'd were the ſame that the Ancient *Grecians* us'd: That the Series of Notes and half Notes was the ſame our Modern Muſic aimed at: Which was there exhibited upon Finger-boards calculated in Mathematical Proportion. This was demonſtrated upon a Viol, becauſe the Strings were of the greateſt Length, and the Proportions more eaſily diſcern'd; but may be accommodated to any Inſtrument, by ſuch mechanical Contrivances as ſhall render thoſe Sounds, which the Muſic requires.

To prove the foregoing Propoſitions, two Viols were Mathematically ſet out, with a particular Fret for each String, that every Stop might be in a perfect Exactneſs: Upon theſe, a Sonata was perform'd by Mr. *Frederick* and Mr. *Chriſtian Stefkins*; whereby it appear'd, that the Theory was certain, ſince all the Stops were owned by them, to be perfect. And that they might be prov'd agreeable to what the beſt Ear, and the beſt Hand performs in modern Practice; the famous *Italian*, Signor *Gaſperini*, play'd another Sonata upon the Violin in Conſort with them, wherein the moſt compleat Harmony was heard.

The full Knowledge and Proof of this Experiment may be found in the two following Tables, wherein Muſic is ſet forth, firſt Arithmetically and then Geometrically: The Mathematician may, by caſting up the Proportions, be ſatisfied that the five ſorts of half Notes here ſet down, do exactly conſtitute all thoſe Intervals, of which our Muſic does conſiſt. And afterwards he may ſee them ſet forth upon a Monochord, where the Meaſure of all the Notes and half Notes comes exactly to the middle of the String. The Learned will find, that theſe are the very Proportions which the old *Greek* Authors have left us in their Writings, and the practical Muſician will teſtify, that theſe are the beſt Notes he ever heard.

The Explication of the Firſt Table.

Between the two loweſt Lines, you have the Series of all the 12 half Notes in an Octave, from A *re* to A *lamire*, which added together make an Octave or exact Duple Proportion: The ſeveral Parts alſo added together make all thoſe Intervals of which it is conſtituted. As for Example, the two half Notes from A to A ※ $\frac{17}{18}$, and from A ※ to B $\frac{16}{17}$ make a Major Tone $\frac{8}{9}$; to which if an Hemitone from B to C $\frac{15}{16}$ be added, you have a leſſer Third $\frac{5}{6}$.

In like Manner between the two next Lines, you have the Series of all the 12 half Notes, in an Octave from C *fa ut* to C *ſol fa ut*: The two firſt Tones added together make a greater Third: And ſo you may add a Tone or Hemitone, till you arrive at every Interval in the Octave, which is ſo call'd, becauſe eight Sounds are required for expreſſing thoſe ſeven gradual Steps, whereby we commonly aſcend to it.

It may be alſo obſerved, that the Proportions falling upon the ſame Notes in two Keys, one Finger-board will be ſufficient for both.

It is acknowledg'd by all that are acquainted either with Speculative or Practical Muſic, that every Interval is divided into two Parts, whereof one is greater than the other: An Eighth $\frac{1}{2}$ into a Fifth $\frac{2}{3}$ and a

Fourth $\frac{3}{4}$. Again, a Fifth $\frac{2}{3}$ into a greater Third $\frac{4}{5}$, and a leſſer Third $\frac{5}{6}$. Thus alſo a greater Third $\frac{4}{5}$ muſt be divided into a Tone Major $\frac{8}{9}$ and a Tone Minor $\frac{9}{10}$. The Leſſer Third (to comply with the Practice of Muſic) is rather compounded of, than divided into a Tone Major $\frac{8}{9}$ and an Hemitone, which is its Complement, $\frac{15}{16}$.

TABLE I.

TABLE the 1ſt. Containing the Proportions ſet out *Arithmetically*.							
						An Eighth	$\frac{1}{2}$
					A Seventh	$\frac{8}{15}$	
				A Sixth	$\frac{3}{5}$		
			A Fifth	$\frac{2}{3}$			
		A Fourth	$\frac{3}{4}$				
	A Greater Third	$\frac{4}{5}$					
	$\frac{8}{9}$	$\frac{9}{10}$	$\frac{15}{16}$	$\frac{8}{9}$	$\frac{9}{10}$	$\frac{8}{9}$	$\frac{15}{16}$
	Tone Major :	Tone Minor	Hemitone	Tone Major	Tone Minor	Tone Major	Hemitone

An Octave with a greater Third. $C\ \frac{17}{18}\ \overset{*}{C}\ \frac{16}{17}\ D\ \frac{19}{20}\ \overset{*}{D}\ \frac{18}{19}\ E\ \frac{15}{16}\ F\ \frac{17}{18}\ \overset{*}{F}\ \frac{16}{17}\ g\ \frac{19}{20}\ \overset{*}{g}\ \frac{18}{19}\ a\ \frac{17}{18}\ \overset{*}{a}\ \frac{16}{17}\ b\ \frac{15}{16}\ c.$

$A\ \frac{17}{18}\ \overset{*}{A}\ \frac{16}{17}\ B\ \frac{15}{16}\ C\ \frac{17}{18}\ \overset{*}{C}\ \frac{16}{17}\ D\ \frac{19}{20}\ \overset{*}{D}\ \frac{18}{19}\ E\ \frac{15}{16}\ F\ \frac{17}{18}\ \overset{*}{F}\ \frac{16}{17}\ g\ \frac{19}{20}\ \overset{*}{g}\ \frac{18}{19}\ a$ An Octave with a leſſer Third $\frac{5}{6}$.

Three Tones Major, two Tones Minor, and two of the aforeſaid Hemitones, placed in the order found in the Scheme, exactly conſtitute the practical Octave; which is ſo call'd, becauſe it conſiſts of eight Sounds, that contain the ſeven gradual Intervals: But it is alſo neceſſary to ſet down the Diviſions of the whole Tones, which are the true Chromatic half Notes, becauſe there is great Uſe of them in Practical Muſic.

To make all our whole Notes, and all our half Notes of an equal Size, by falſifying the Proportions, and bearing with their Imperfections, as the common Practice is, may be allow'd by ſuch Ears, as are vitiated by long Cuſtom: But it certainly deprives us of that ſatisfactory Pleaſure, which ariſes from the Exactneſs of ſonorous Numbers; which we ſhould enjoy, if all the Notes were truly given according to the Proportions here aſſign'd.

It is very eaſie to ſatisfie our ſelves in the Arithmetical Scheme, by thoſe Operations, which *Gaſſendus* has ſet down in his *Manuduction* to the *Theory* of *Muſic*, Tom. V. pag. 635. As for Example, his Rule for Addition is, That two Proportions being given, if the greater Number of one be multiplied by the greater Number of the other, and the leſſer by the leſſer, the two Numbers produc'd exhibit the compounded Proportions. Thus take a Practical Fifth $\frac{3}{2}$ and a Practical Fourth $\frac{4}{3}$ for the two Proportions given, multiply 3 by 4 and you have 12: then multiply 2 by 3 and you have 6: which compounded Proportion of 12 to 6 makes the Practical Octave $\frac{2}{1}$.

Thus, according to his Arithmetical Operations of Addition, Subtraction, Multiplication, of Continuation and Diviſion, is our whole Syſtem proved, which for the more eaſy Application to Practical Muſic, ſhall be alſo ſet forth Geometrically upon the ſix Strings of a Viol.

The Explication of the Second Table.

Theſe ſix Lines repreſent the ſix Strings of the Viol in the common Tuning.

The ſounding Part of each String from the Nut to the Bridge is ſuppos'd to be 30 Inches long; the two middle Strings C and E are drawn out to 15 Inches, the half of the whole.

'Tis eaſie to meaſure every Interval with a Pair of Compaſſes. Suppoſe you are to take the 20*th* Part of the String G; 'tis an Inch and a half for the firſt half Note; if you take the whole Note from G to A, 'tis the tenth Part, and muſt be three Inches.

After theſe are taken away, your String will be but 27 Inches long, ſo that if you advance one Note, or a Major Tone further, you muſt take a 9*th* Part of it, which will be three Inches more, whereby you arrive at a greater Third, being the fifth Part of the whole String. Thus the Series of all the Notes may be demonſtrated.

All the Strings are Uniſon at the Stops where the tuning requires: So that though the Proportions be carried on as far as the Frets allow, yet the String is open the ſame with the Stop of that String to which it is tuned; and accordingly the Series of the Notes proceeds as if they were all upon a Monochord.

This Calculation ſerves but for two Keys *A* and *C*, which are called Natural, becauſe they have no eſſential Flats or Sharps.

But becauſe the Compoſer begins upon any Key, and the Series of Notes muſt take its *terminus à quo* from thence; the Inſtrument-maker can provide ſuch moveable Finger-boards as will ſerve exactly for every Key. They are taken out and put in upon the Neck of the Viol, with as much Eaſe as you pull out and thruſt in the Drawer of a Table. Three, or at moſt five of them, will be ſufficient to accommodate all the Keys that are made uſe of.

This Mathematical fixing of the Frets enables every Practitioner, who ſtops cloſe to them, to give the Proportions of the Notes in a greater Exactneſs, than can be done upon the Baſs-Violin, or Violin itſelf: Since they may be ſet forth more perfectly by a Pair of Compaſſes dividing a Line, than the niceſt Ear can direct.

Though the Frets for the ſeveral Strings do not ſtand in a ſtrait Line, and the Places are alſo ſhifted in different Keys, yet the Ear naturally directs the Fingers to them; inſomuch that thoſe Perſons, who have all their Lives Time been accuſtom'd to ſtop upon Frets, that go quite croſs the Finger-boards of their Inſtruments, do with very little Practice fall right upon theſe. Such is the Power of a muſical Genius, as may be undeniably proved by thoſe that play upon the Violin; who, when they change the Key, fall upon the right Stops, though they have no viſible Direction where to ſtop, nor Time to alter, by the Ear, the Note they firſt pitched upon.

By this Standard of Regular Proportions may the Voice be formed to ſing the pureſt Notes; they are all the ſame in Vocal and Inſtrumental Muſic; if then the Inſtrument which governs the Voice be perfect, the Ear will of Neceſſity bring it to Perfection. It is pity that a good natural Voice ſhould be taught to ſing out of Tune, as it muſt do, if it be guided by an imperfect Inſtrument; and this may be the Reaſon why ſo few attain to that Melody, which is ſo much valued; but ſince we now know wherein Perfection lies, a conſtant Practice will come to the Attainment of it. The dividing Wholes into Chromatic Hemitones is very neceſſary, but very difficult for the Voice to be broken to: If it learns from an Inſtrument whoſe whole Notes, and whoſe half Notes are ſuppoſed to be equal, the Sound muſt needs be very uncertain and unharmonical; whereas the Proportions truly fixed, would bring it to a Perfection in the niceſt and moſt charming Part of Muſic.

The Chromatic Hemitones are the ſmalleſt Intervals our modern Muſic aims at, though the Ancients had their Enharmonic quarter Notes, which they eſteem'd their greateſt Excellency: Theſe may alſo in Time be recover'd, ſince we know their Proportions; for as the Diatonic Tone is divided into Chromatic Hemitones, ſo after the ſame manner may the Chromatic Hemitones be divided into thoſe leaſt Enharmonic Intervals, which were ever made Uſe of. But if we go no further, yet this Experiment demonſtrates the true Theory of Muſic, and brings the Practice of it to the greateſt Perfection.

Of the Ancient Greek *and* Roman Lyre; *and a* Paſſage *in* Horace *explain'd by Dr.* T. Molyneux, n. 282. p. 1267.

II. Reading over lately the *Third* Ode of the *Fourth* Book of *Horace*, which *Scaliger*, *Dacier*, and the reſt of the Critics and Commentators ſo much admire, I hit upon a Paſſage, which I think none of them (and I have examin'd the Chief) have clearly explain'd. The *Ode* begins:

Quem tu Melpomene, &c.

The Paſſage I ſpeak of is this;

O Teſtudinis Aureæ
Dulcem quæ ſtrepitum, Pieri, temperas!
O Mutis quoque Piſcibus
Donatura Cygni, ſi libeat, ſonum!

At firſt it ſeem'd to me a wild Rant, or extravagant Whim for *Horace*, ſo great a Judge and Maſter in the Art of Poetry, ſo particularly remark'd for his Propriety of Thought, in ſo labour'd and exquiſite a Poem, to ſay that his Muſe could give even to *Mute Fiſhes* the melodious Voice of the Swan; I look'd upon the Fancy as perfectly forc'd and groundleſs, founded upon nothing that was real or true in Nature: But upon a ſecond Conſideration, I fancied this might be the Meaning of the Paſſage;

That, after he had in the Verſes going before, acknowledged how much he was indebted to the Bounty of his Muſe, he here makes a ſudden Exclamation to extol her great Art and Myſtery, who by mixing various Notes, could compoſe ſuch ſweet Harmony on the *Gilded Lyre* or *Teſtudo*, and by her ſurprizing Power, could give even to *Mute Fiſhes*, or the hollow Shells of the *Teſtudines Aquaticæ* or *Water Tortoiſes*, (a Sort of Fiſh of which I imagin'd they made their *Lyres* in old Times) the ſweet Melody of the Swan. As for the Compariſon to the Voice of a *dying Swan*, though that be a Fiction, yet a Vulgar Error univerſally embrac'd, was ever ſufficient Authority for a Poet or Orator to draw from it a Compariſon or a Simile.

This put me upon ſearching for Matter of Fact, whether or no the ancient Lyre was made of the Shell of a Tortoiſe; and looking into ancient Authors, I find that it was a current Piece of Hiſtory generally received among the Ancients, that *Mercury* was the firſt Inventor of the *Lyre* (whence *Horace* in his 10th Ode of the 1ſt Book ſtyles him *Curvæ Lyræ Parentem*) and that he made it of the Shell of a dead *Tortoiſe*, which he accidentally found on the Banks of the River *Nile*. Out of many, I will produce two Teſtimonies to this Purpoſe;

Nicander, who wrote above 100 Years before *Horace*, in his *Alexipharmaca*, ſpeaking of Antidotes proper againſt the Poiſon of the *Salamander*, recommends both the *Sea* and the *Mountain Tortoiſe* in theſe Words,

Ἀμμίγδην ἀλίοιο καθεψηθέντα χελώνης
Πυίοις, ἢ ταχινῆσι διαπλώει πτερύγεσσιν,
Ἄλλοτε δ᾽ οὐρείης κυτισηνόμου, ἥν τ᾽ ἀκάκητα
Αὐδήεσσαν ἔθηκεν ἀνάυδητον πέρ ἐοῦσαν
Ερμείης, ζαρκὺς γὰρ ἀπονόσφισε χελεῖον
Ἄιολον, ἀγκῶνας δὲ δύω παρετείνατο πέζαις

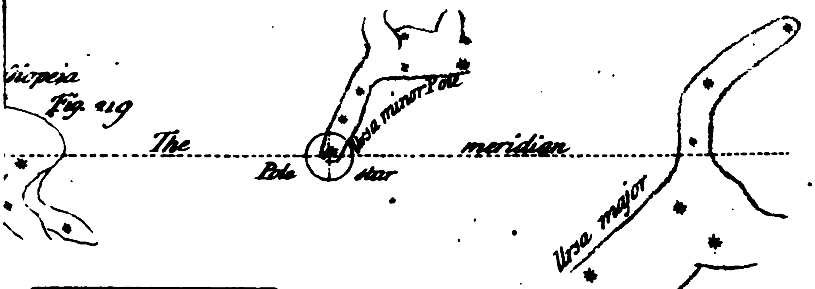


Fig. 219

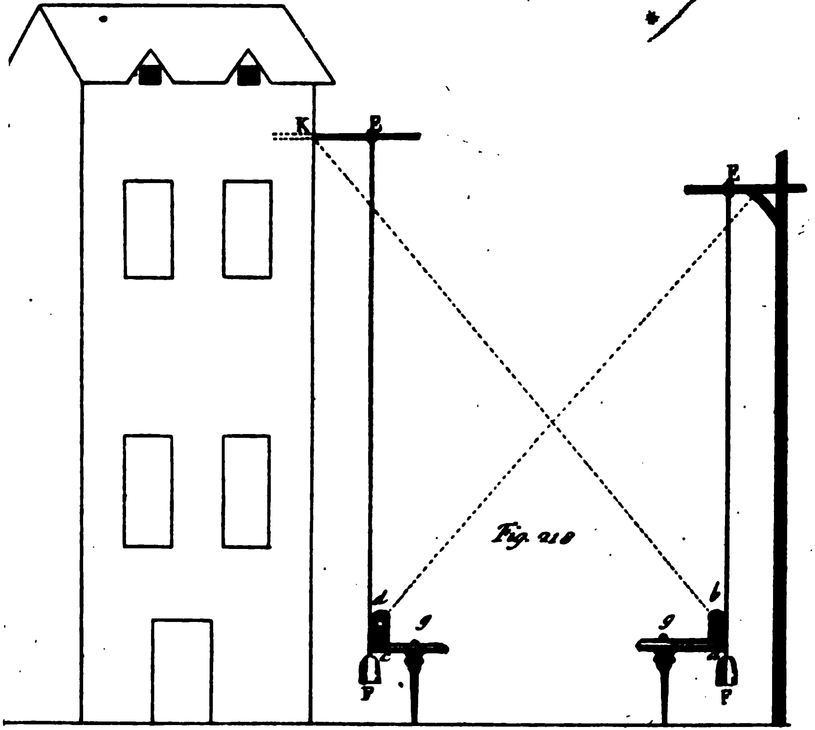


Fig. 218

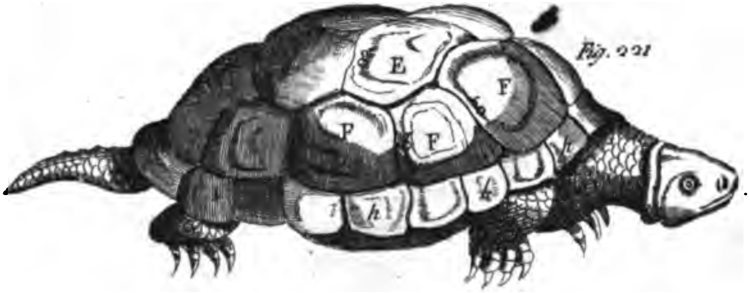


Fig. 221

Thus turn'd by *Joannes Gorræus,*

Cum curvâ auxilio veniunt Teſtudine——
Quæ Pelagi fluctus velocibus innatat alis,
Aut montana etiam Cytiſo quæ veſcitur, & quam
Reddidit e muta modulanti voce canoram
Mercurius, picto inſontis qui Cortice carnem
Exemit, geminumq; Ancona intendit in oris.

Grevinus in his Treatiſe *de Venenis* in the Chapter *de Salamandra*, pag. 119. gives us a Comment on theſe Verſes, and relates at large the Hiſtory of the firſt Lyre, but I cannot but take Notice that this Verſe

Αὐδήεσσαν ἔθηκεν ἀναύδητόν περ ἐοῦσαν;
Reddidit e muta modulanti voce canoram——Is ſo home and appoſite to our Purpoſe, and comes up ſo cloſe to *Horace*'s Thought,

O mutis quoque Piſcibus
Donatura Cygni ſi libeat ſonum,

that it does not only explain the true Meaning of it, but makes me inclinable to believe, that *Horace* might have in his View this very Paſſage; which he ſeems alſo again to allude to (though not ſo fully and expreſly) in his 11*th* Ode of the 3*d* Book, where he invokes his Lyre,

Tuque Teſtudo reſonare ſeptem
Callida nervis,
Nec Loquax olim neque grata ——

The other Inſtance is from one of *Lucian*'s Dialogues, who writ above a hundred Years after *Horace*; whence 'tis plain the Mechaniſm of the ancient Lyre, and the Opinion concerning its firſt Invention, prevail'd ſince, as well as before, *Horace*'s Days. In this Dialogue he introduces *Apollo* and *Vulcan* talking after his jocoſe way of *Mercury* to this Purpoſe.

Απ. χελώνην πȣ̈ νεκρὰν εὑρὼν, ὄργανον ἀπ' αὐτῆς συνεπήξατο, πήχεις γὰρ ἐναρμόσας, καὶ ζυγώσας, ἔπειτα καλάμους ἐμπήξας, καὶ μαγάδιον ὑποθεὶς, κατὰ ὀντεινάμενος ἑπτὰ χορδὰς, μελῳδεῖ πάνυ γλαφυρὸν, ὦ Ἥφαιστε, καὶ ἐναρμόνιον.

Ap. *Teſtudinem mortuam alicubi offendens Inſtrumentum ex ea concinnavit; Brachia enim adaptans Jugum oppoſuit, deinde Clavos inſigens, & Hæmiſphærium repandum infra ſubjiciens, ſeptem Chordas extendebat, atq; modulabatur quiddam valde ſonorum, O Vulcane, & ad Muſicæ Melodiam compoſitum.*

Fig. 220. is taken from Father *Merſennus* (*Lib.* 1. *de* Inſtrumentis, *p.*7.) Fig. 220. which he tells us he copied from the Sculpture of an antique Gem, that belong'd to one *Jacobus Gaffarellus*. *A*, *A*, ſhew the πήχεις of *Lucian*, the Ἀγκῶνες or *Brachia* of *Nicander*, made of the Horns of ſome Beaſt. *B* the Ζυγὸς, or *Jugum*, in which were faſtened the κάλαμοι *Clavi*, Pegs that raiſed or depreſt *c*, *c*, the χορδαὶ, or Strings, which were fix'd at their t'other End to *D* the μαγάδιον *Hemiſphærium* or Belly: This is very like *Figure* 221. which is an entire *Teſtudo Aquatica* or rather *Fluviatilis*, taken from *Johnſtonus de Animalibus* as delineated in his *eightieth* Table *de Quadrupedibus*; making Allowances for their different Poſture, one being repreſented full and flat, whilſt only half of the other appears becauſe 'tis ſhewn ſide-ways. Fig. 221.

Fig. 220. Fig. 221. The Belly of *Merſennus*'s Lyre mark'd *D*, agrees nicely in Figure and Shape with the Back or Shell of *Johnſtonus*'s *Teſtudo Aquatica*, mark'd *E*. They are both curiouſly teſſelated, checker'd into Areas or Scales *F*, *F*, *F*, *F*, *F*, *F*, of ſomewhat a Square Figure; and each of theſe Scales again in both is neatly wrought about their Edges with a Line running parallel to their Margins *g*, *g*, *g*, *g*, *g*, *g*; and the Shell of the Lyre, as that of the Tortoiſe, terminates in a narrow Limb or Verge, cut into ſmaller Scales *b*, *b*, *b*, *b*, *b*, *b* incompaſſing the whole: ſo that both theſe Figures, though drawn by different Artiſts, perhaps at two thouſand Years Diſtance, do manifeſtly own the Lineaments of the ſame natural Original.

Pauſanias too in his Deſcription of *Greece* (as I find it quoted by *Geſner*) mentions a Mountain in *Arcadia* called *Parthenius Mons*, *qui Teſtudines exhibet ad compingendas Lyras aptiſſimas*; and in another Place, *Arcadum Querceta ingenti magnitudine Teſtudines exhibent*, *ex quibus Lyras conſiceres æquales illis quæ ex Indica Teſtudine componuntur*. From whence 'tis plain the Ancients made their *Lyres* of the Shells of *Tortoiſes*, perhaps not very curious in the Choice of their Materials, but might take promiſcuouſly the *Land* or *River Tortoiſe*, which occaſions *Pauſanias* and *Nicander* to mention the *Mountain*, whereas *Horace* ſpeaks of the *River Tortoiſe*.

And indeed moſt of the Inſtruments, *&c.* now in Uſe were at firſt rude, plain, and ſimple, tho' improv'd by Length of Time, and Fancy of Artificers: Thus the *Flute*, *Flagelet*, *Hautboy*, and *Organs*, are only Improvements of the *Tenues Avenæ* or *Oaten-Pipes* of the Field, or the *Calami impares Juncti* of the Ancients, *Reeds* of unequal Lengths rudely put together; thus their Trumpets were at firſt made only of rude *Horns* of Beaſts, and ſometimes of the common *Buccina Whelks* or large Sea-ſhells, hence *Virgil*,

Rauco ſtrepuerunt Cornua cantu. And *Perſius*,
Buccina jam priſcos cogebat ad arma Quirites.

And thus their Lyres were at firſt made of the Tortoiſe-Shell; tho' in After-Ages the Number of the Strings was encreaſed, and the Model alter'd; and the Inſtrument tho' improv'd, and very unlike its firſt Original, yet ſtill retain'd its Ancient Name.

This appears from thoſe other Schemes *Merſennus* gives in the ſame Table of ſeveral Sorts of the ancient Lyres (but theſe I take to be more Modern than that which is here expreſt) and from thoſe deſcrib'd by *Leonardo Agoſtini*, in the Second Part of his Collection of the *Gemme Antiche*, which ſhew us, that as the Fancy of the Workman, the Mode of the Times, real Convenience or an imaginary Beauty in the Inſtrument determin'd it, they were faſhion'd into various Shapes, and frequently like their Lamps of Old into capricious, fantaſtical odd Figures.

The End of the FIRST PART.

The Philoſophical Tranſactions

ABRIDG'D.

PART II.

Containing the

PHYSIOLOGICAL PAPERS.

CHAP. I.

Phyſiology. Meteorology. Pneumatics.

A Scale of the Degrees of Heat, *by* . . . n.270. p.824.

0		I. THE Heat of Winter Air, when Water begins to freeze. This Heat is known by rightly placing the Thermometer in Snow preſſed together, at what Time it begins to thaw.
0, 1, 2.		The Heat of Winter Air.
2, 3, 4.		The Heat of the Air in Spring and Autumn.
4, 5, 6.		The Heat of the Air in Summer.
6.		The Heat of the Air at Noon, about the Month of *July*.
12.	1	The greateſt Heat that the Thermometer receives by the Contact of a Human Body. This Heat is much the ſame as that of a Bird ſitting upon her Eggs.
$14\frac{3}{11}$	$1\frac{1}{4}$	The Heat of a Bath, which is almoſt the greateſt that any one can endure long, with his Hand agitated and immerſed in it. The ſame almoſt is the Heat of Blood juſt let out.
17	$1\frac{1}{2}$	The greateſt Heat of a Bath that any one can endure long, his Hand being immerſed and at reſt in it.
$20\frac{2}{11}$	$1\frac{3}{4}$	The Heat of a Bath in which Wax ſwimming and melting, by moving about grows hard and loſes its Tranſparency.
24	2	The Heat of a Bath in which Wax ſwimming grows liquid by the Heat, and is preſerved in continual Flux without Ebullition.
$28\frac{6}{11}$	$2\frac{1}{4}$	The intermediate Heat between the Degrees in which the Wax melts and the Water boils.
34	$2\frac{1}{2}$	The Heat by which Water boils violently, and a Mixture of two Parts of Lead, of three Parts of Pewter, and

		and of five Parts of Biſmuth grows ſtiff in cooling. Water begins to boil by a Heat of 33 Parts, and in boiling conceives a Heat of more than 34½ Parts. But Iron with a Heat of 35 or 36 Parts ceaſes to excite an Ebullition, when hot Water is dropt upon it; and of 37 Parts, when cold Water does the ſame.
$40\frac{4}{11}$	$2\frac{1}{4}$	The leaſt Heat by which a Mixture of one Part Lead, of four Parts Pewter, and of five Parts Biſmuth, grows hot and melts, and is preſerved in a continual Flux.
48	3	The leaſt Heat by which a Mixture of equal Parts of Pewter and Biſmuth melts. This Mixture cools and coagulates by a Heat of 47 Degrees.
57	$3\frac{1}{4}$	A Heat by which a Mixture of two Parts of Pewter, and one Part of Biſmuth is melted, as alſo a Mixture of three Parts of Pewter, and two Parts of Lead. But a Mixture of five Parts of Pewter, and of two Parts of Biſmuth, cools and grows ſtiff with this Heat. And a Mixture of equal Parts of Lead and Biſmuth does the ſame.
68	$3\frac{1}{2}$	The leaſt Heat by which a Mixture of one Part of Biſmuth, and eight Parts of Pewter is melted. Pewter alone is melted with a Heat of 72 Parts, and cools and grows ſtiff by a Heat of 70 Parts.
81	$3\frac{3}{4}$	The Heat by which Biſmuth is melted, as alſo a Mixture of four Parts of Lead, and one Part of Pewter. But a Mixture of five Parts of Lead, and one Part of Pewter, grows ſtiff when melted, and cools in this Heat.
96	4	The leaſt Heat by which Lead is melted. Lead grows hot and melts in a Heat of 96 or 97 Parts, and cools and grows ſtiff in a Heat of 95 Parts.
114	$4\frac{1}{4}$	The Heat by which Bodies heated in the Fire by cooling quite leave off to ſhine in the Darkneſs of the Night, and again by growing hot begin to ſhine in the ſame Darkneſs, but with a very faint Light which can hardly be perceived. In this Heat a Mixture of equal Parts of Pewter and Regulus Martis will melt; but a Mixture of ſeven Parts of Biſmuth, and four Parts of the ſame Regulus Martis, will cool and grow ſtiff.
136	$4\frac{1}{2}$	The Heat by which Bodies heated in the Fire grow red hot, but not ſo in the Twilight. By this Heat a Mixture of two Parts of Regulus Martis, and of one Part of Biſmuth, as alſo a Mixture of five Parts of Regulus Martis, and one Part of Pewter, by cooling grows ſtiff. The Regulus by itſelf grows ſtiff with a Heat of 146 Degrees.

161	4¼	The Heat by which Bodies heated in the Fire plainly grow red hot in the Twilight, juſt before the Riſing or Setting of the Sun, but not ſo in open Day-light, or but very obſcurely.
192	5	The Heat of burning Coals in a ſmall Kitchen Fire, made of bituminous foſſile Coals, and without blowing with Bellows. The ſame is the Heat of Iron in ſuch a Fire, that grows red hot as much as it can. The Heat of a ſmall Culinary Fire made of Wood is ſomething greater, perhaps of 200 or 210 Degrees. But the Heat of a large Fire is ſomething greater ſtill, eſpecially if provoked by the Uſe of Bellows.

In the firſt Column of this Table we have the Degrees of Heat in Arithmetical Progreſſion, beginning the Computation from that Degree in which Water begins to freeze, as it were from the loweſt Degree of Heat, or the common Limit of Heat and Cold, and making the external Heat of a Human Body to be 12 Degrees. In the ſecond Column are had the Degrees of Heat in Geometrical Progreſſion, ſo that the ſecond Degree is as great again as the firſt, the third as great again as the ſecond, and ſo on; and the firſt is the external Heat of the Body of a Man adequate to Senſe. Now it appears from this Table, that the Heat of boiling Water is almoſt three Times greater than the Heat of the Human Body, and that the Heat of melted Pewter is ſix Times greater, and the Heat of melted Lead is eight Times greater, and the Heat of melted Regulus is twelve Times greater, and that the ordinary Heat of a Culinary Fire is 16 or 17 Times greater, than the ſame Heat of a Human Body.

This Table was conſtructed by the help of a Thermometer and a piece of red hot Iron. By the Thermometer I found the Meaſure of all the Degrees of Heat, till I came to the Heat with which Pewter is melted, and by the red hot Iron I found the Meaſure of the reſt. For the Heat which red hot Iron communicates to cold Bodies which are contiguous to it, in a given time, that is, the Heat which the Iron loſes in a given time, is as the whole Heat of the Iron. Therefore if the Times of cooling are taken equal, the Heats will be in a Geometrical Ratio, and therefore are eaſily found by a Table of Logarithms.

Therefore firſt I found, by a Thermometer conſtructed with Linſeed Oyl, that when the Thermometer was put into melting Snow, the Oyl took up a Space of 10000 Parts. The ſame Oyl rarified by a Heat of the firſt Degree, or by that of a human Body, took up the Space 10256; and by the Heat of Water juſt beginning to boil, it took up the Space 10705, and by the Heat of Water boiling vehemently it took up the Space 10725, and by the Heat of melted Pewter cooling, when it began to be ſtiff and put on the Conſiſtence of an Amalgama, it took up the Space 11516, and the Space 11496 when it was quite ſtiff. Therefore the rarified Oyl was to the dilated in the

Ratio of 40 to 39, by the Heat of the human Body; in the Ratio of 15 to 14 by the Heat of boiling Water; in the Ratio of 15 to 13 by the Heat of cooling Pewter, when it began to grow ſtiff and coagulate; and in the Ratio of 23 to 20 by the Heat by which cooling Pewter grows quite ſtiff. The Rarefaction of Air with equal Heat was ten times greater than the Rarefaction of Oyl, and the Rarefaction of Oyl was about 15 times greater than the Rarefaction of Spirit of Wine. And from what is here found, by ſuppoſing the Heat of the Oyl proportional to its Rarefaction, and for the Heat of the human Body writing 12 Degrees, the Heat of Water when it begins to boil will come out 33 Degrees, and when it boils vehemently 34 Degrees; and the Heat of Pewter either when it melts, or when it begins to cool and becomes of the Conſiſtency of an Amalgama, will be of 72 Degrees, and when it cools and grows hard, of 70 Degrees.

Theſe things being known, that I might find the reſt, I heated a thick piece of Iron till it was red hot, and taking it out of the Fire with a hot pair of Pincers, I immediately put it in a cold Place, where the Wind blew conſtantly; and putting upon it little Particles of different Kinds of Metals, and other Bodies that would melt, I obſerved the Times of Cooling, till all the Particles grow ſtiff and loſt their Fluidity, and the Heat of the Iron was equal to the Heat of the human Body. Then ſuppoſing that the Exceſſes of the Heat of the Iron and the rigid Particles above the Heat of the Atmoſphere found by the Thermometer, are in Geometrical Progreſſion when the Times are in Arithmetical Progreſſion, all the Degrees of Heat became known. I placed the Iron in a Wind blowing uniformly, and not in a quiet Air, that the Air heated by the Iron might always be carry'd away by the Wind, and the cool Air might ſucceed in its Place with an uniform Motion. For thus equal Parts of the Air would be made hot in equal Times, and would conceive a Heat proportional to the Heat of the Iron.

Now the Heats thus found will have the ſame Proportion to one another with the Heats found by the Thermometer, and therefore we have rightly aſſumed, that the Rarefactions of the Oyl are proportional to its Heat.

An Account of Dr. Hook's *Marine Barometer, by Mr.* E. Halley, n. 269. p. 791.

II. Dr. *Hook*, who has made many Attempts to improve the *Barometer*, and to render the minute Diviſions on the Scale thereof more ſenſible, judging that it might be of great Uſe at Sea, contrived ſeveral Ways to make it ſerviceable on Board a Ship; one of which he explained to the *Royal Society* at their weekly Meeting in *Greſham-College*, *January* 2. 166$\frac{7}{8}$. ſince which Time he hath further cultivated the Invention, and ſome Years ago produced before the ſaid *Society*, the Inſtrument I am now to deſcribe.

The Mercurial Barometer requiring a perpendicular Poſture, and the Quickſilver vibrating therein with great Violence upon any Agitation, is therefore uncapable of being uſed at Sea, (though it hath lately been contrived to be made portable.) So it remained to find out ſome other Principle, wherein the Poſition of the Inſtrument was not ſo indiſpenſably neceſſary: For this, all thoſe that uſe the Sea are obliged to the great Facility Dr. *Hook* has always ſhewn, in applying philoſophical Experiments to their proper Uſes.

It is about 40 Years ſince, that the *Thermometers* of *Robt. de Fluctibus*, depending on the Dilatation and Contraction of included Air by Heat and Cold, have been diſuſed, upon Diſcovery that the Air's Preſſure is unequal; that Inequality mixing itſelf with the Effects of the Warmth of the Air in that Inſtrument. And inſtead thereof was ſubſtituted the ſeal'd Thermometer, including Spirit of Wine (firſt brought into *England* out of *Italy* by Sir *Robert Southwell)* as a proper Standard of the Temper of the Air in relation to Heat and Cold; that æthereal Spirit being of all the known Liquors the moſt ſuſceptible of Dilatation and Contraction, eſpecially with a moderate Degree of either Heat or Cold. Now this being allowed as a Standard, and the other Thermometer that includes Air being graduated with the ſame Diviſions, ſo as at the Time when the Air was included, to agree with the Spirit-Thermometer in all the Degrees of Heat and Cold, noting at the ſame Time the preciſe Height of the Mercury in the common Barometers: It will readily be underſtood, that whenſoever theſe two Thermometers ſhall agree, the Preſſure of the Air is the ſame it was, when the Air was included and the Inſtrument graduated: That if in the Air-Thermometer the Liquor ſtand higher than the Diviſion marked thereon, correſponding with that on the Spirit-Glaſs, it is an Indication that there is a greater Preſſure of the Air at that Time, than when the Inſtrument was graduated. And the contrary is to be concluded, when the Air-Glaſs ſtands lower than the Spirit, *viz.* that then the Air is ſo much lighter, and the Quickſilver in the ordinary Barometers lower than at the ſame Time of Graduation.

And the Spaces anſwering to an Inch of Mercury will be more or leſs, according to the Quantity of Air ſo included, and the Smallneſs of the Glaſs Cane, in which the Liquor riſes and falls, and may be augmented almoſt in any Proportion, under that of the ſpecific Gravity of the Liquor of the Thermometer to Mercury. So as to have a Foot or more for an Inch of Mercury, which is another great Convenience.

It has been obſerved by ſome, that in long keeping this Inſtrument, the Air included either finds a Means to eſcape, or depoſits ſome Vapours mix'd with it, or elſe for ſome other Cauſe becomes leſs elaſtic, whereby in Proceſs of Time it gives the Height of the Mercury ſomewhat greater than it ought; but this, if it ſhould happen in ſome of them, hinders not the Uſefulneſs thereof, for that it may at any Time very eaſily be corrected by Experiment, and the riſing and falling thereof are the Things chiefly remarkable in it, the juſt Height being barely a Curioſity.

In theſe Parts of the World, long Experience has told us, that the riſing of the Mercury forbodes fair Weather after foul, and an Eaſterly or Northerly Wind, and that the falling thereof, on the contrary, ſignifies Southerly or Weſterly Winds, with Rain, or ſtormy Winds, or both; which latter is of much more Conſequence to provide againſt at Sea than at Land; and in a Storm, the Mercury beginning to riſe, is a ſure Sign that it begins to abate, as has been experienced in high Latitudes both to the Northwards and Southwards of the Equator.

Fig. 1. *A B* repreſents the Spirit-Thermometer, graduated from 0, or the freezing Point, through all the poſſible Degrees of the Heat or Cold of the Air, at leaſt in theſe Climates.

C D is the Air-Thermometer, graduated after the ſame Manner, with the like Degrees.

E F is a Plate applied to the Side of the Thermometer *C D*, graduated into Spaces anſwering to Inches and Parts of an Inch of Mercury, in the common Barometers.

G, a Hand ſtanding on the Plate at the Height of the Mercury thereon, as it was when the Inſtrument was graduated, as ſuppoſe here at 29½ Inches.

L M a Wire on which the Plate *E F* ſlips up and down, parallel to the Cane of the Thermometer *C D*.

K, any Point at which the Spirit ſtands at the Time of Obſervation; ſuppoſe at 38 on the Spirit-Thermometer; ſlide the Plate *E F* till the Hand *G* ſtand at 38 on the Air-Thermometer, and if the Liquor therein ſtand at 38 likewiſe, then is the Preſſure of the Air the ſame as at the Time of Graduation; *viz*.. 29, 5; but if it ſtand higher, as at 30 at I, then is the Preſſure of the Air greater; and the Diviſion on the ſliding Plate againſt the Liquor, ſhews the preſent Height of the Mercury to be 29 Inches 7 Tenths.

I had one of theſe Barometers with me in my late Southern Voyage, and it never failed to prognoſtick and give early Notice of all the bad Weather we had.

A New *Baroſcope, by Mr.* Caſwell. n. 290. p. 1597. Fig. 2. III. I have made a new Sort of Baroſcope, 'tis cheap and very exact, I here ſend you its Calculation as it occurr'd to my Thoughts before I made it. Suppoſe *A B C D* is a Bucket of Water, in it the Baroſcope *x r e z y o s m*, which conſiſts of a Body *x r s m*, and a Tube *e z y o*, the Body and Tube are both concave Cylinders communicating with each other, and made of Tin (for Want of Glaſs:) The Bottom of the Tube *z y* has a Lead-weight to ſink it, ſo that the Top of the Body may juſt ſwim even with the Surface of the Water by the Addition of ſome Grain-Weights on the Top. The Water when the Inſtrument is forced with its Mouth downwards gets up into the Tube to the Height *y u*. There is added on the Top a ſmall concave Cylinder, which I call the Pipe, to diſtinguiſh it from the Bottom ſmall Cylinder, which I call the Tube: This Pipe is to ſuſtain the Inſtrument from ſinking to the Bottom, md is a Wire, mS, dE are two Threads oblique to the Surface of the Water, which Threads perform the Office of Diagonals: For that while the Inſtrument ſinks more or leſs by the Alteration of the Gravity of the Air, there, where the Surface of the Water cuts the Thread, is form'd a ſmall Bubble, which Bubble aſcends up the Thread, while the ☿ of the common Baroſcope aſcends.

The Circumference of the Body is 21 Inches, therefore its Area $= 35$: the Altitude $ms = 4$, therefore the Body's Solidity $= 140$, each Baſe xm, rs, has a Convexity whoſe Altitude is 6.5, therefore the Conoid on each Baſe is nearly $= 11\frac{1}{2}$, therefore d the whole Body is $= (140 + 11\frac{1}{2} + 11\frac{1}{2} =)$ 163, and b the entire Altitude of the Body $= (4 + .65 + .65 =)$ 5.3. The inner Circumference of the Tube is 5.014, therefore its Area $n = 2$ the Length of the Tube $= 45$, therefore the Tube's Capacity $= 9$, therefore C, the Content of the Body and Tube $= 163 + 9 = 172$ Cubic Inches, that is almoſt $2\frac{1}{2}$ Quarts.

Suppoſe the Air's Preſſure when greateſt $= 30.5$ Inches of ☿ $= (30.5 \times 14 =)$ 427 of Water, and $f = 427$, therefore $fc = 73444$. Put a for the Depth oa, of the Air in the Tube when the Body is juſt all immerſed, the Air in the Inſtrument on Immerſion contracts ſomewhat by the Cold of the Water; this Contraction I find is nearly as much as would be produc'd by an Addition of 1 Inch to the Atmoſphere's Altitude 427; this in cold Weather, but in warm Weather 'tis probably twice as much: But we will now ſuppoſe it $= 1$, therefore the Depth of the Surface of the Water in the Tube below the Surface of the outer Water is $= b + a$, therefore the Preſſure on that inner Surface, is as the Altitude of the Atmoſphere above it $= f + b + 1 + a = F - a$ (putting $F = f + b + 1$.) Then for that the Spaces into which the Air is contracted, are reciprocal to their reſpective Preſſures, and for that while the Inſtrument is out of the Water, the Preſſure f anſwered to the Space C, therefore,

$F + a : f :: C : \frac{fc}{F + a} =$ Space which the Air takes up in the Inſtrument under Water; therefore, $\frac{fc}{F + a} - d =$ that Part of the Tube which is poſſeſſed by Air $= an$ (ſuppoſing the Tube's Area $2 = n$).

Therefore $fc - Fd - ad = Fan + aan$. Therefore $aa + F + \frac{d}{n}$

$\times a = \frac{fc - Fd}{n}$. Put $F + \frac{d}{n} = 2g$, therefore $aa + 2ga$, $= \frac{fc - Fd}{n}$ therefore $a = \sqrt{: \frac{fc - Fd}{n} + gg} - g$.

Then ſuppoſe the Atmoſphere's Gravity leſs, ſo much as to ſink the ☿ $\frac{1}{10}$ Inch $= 1.4$ of Water, and therefore putting $\varphi = F - 1.4$, and in the laſt Equation α inſtead of a, and γ inſtead of g, you have $\alpha = \sqrt{\frac{fc - \varphi d}{n} + \gamma\gamma} : - \gamma$. Thus I find $\left.\begin{matrix} a = 2.72 \\ \alpha = 2.94 \end{matrix}\right\}$ and therefore $\alpha - a = .22$, which $.22 \times n$ gives $.44$ Cubic Inches, and (ſuppoſing a Cube-Inch $= 253$ Grains) $.44 \times 253 = 111$ Grains Weight of Water that was gotten up into the Tube in the firſt Caſe more than in the ſecond, and therefore the Baroſcope requires an Addition of 111 Grains on its Top to ſink it with the Level of the Water in the ſecond Caſe more than in the firſt, and this upon the ſinking of the ☿ in the common Baroſcope only $\frac{1}{10}$ Inch; now 1 Grain in this new Baroſcope is nearly as diſcernable as $\frac{1}{10}$ Inch in the common, and therefore this new Baroſcope is more exact than the common 111 Times.

Put $f = 247$.$c = 172$.$d = 163$.$n = 2$ as above, only change F, put F, put F 437.3, that is, ſuppoſe the Body ſunk in Water 4 Inches lower; in this Caſe $\alpha = 208$, therefore $a - \alpha = .64$, which multiplied into $\varphi n = 1.28$ Cubic-Inches, which $\times 253$ gives 324 Grains, and ſo much the Body's Top xm being ſunk 4 Inches under Water, the Body becomes heavier, than while xm was at the Surface of the Water. Therefore this 1.28 divided by the aforeſaid Depth 4 gives .32 the Area of the Top-Pipe, ſuch as would ballance or buoy up the Body at any Depth. Strictly ſpeaking, the Pipe ſhould be gradually bigger upward in order to ſuſtain the Inſtrument at any Depth, but as to Senſe it is cylindrical, and its Circumference $= 2.005$. But for that the leaſt Alteration of the Air would make the Body's Top xm in that Caſe paſs through the 4 Inches (which 4 Inches I ſuppoſe, all the Variety of Depth that the Inſtrument has room given it in the Bucket to aſcend or deſcend) therefore the Pipe is made a ſmall Matter bigger, (*viz.*) its Circumference is 2.14; whereby the Pipe, according as the Body ſinks more, gives more Reſiſtance to the deſcending Body. The Pipe's Area is .3643; therefore the Capacity of the Pipe in 4 Inches Altitude is $= 1.457$. But as aboveſaid to give juſtly no Reſiſtance, its Capacity ſhould be 1.28. Therefore this 1.28 taken from 1.457, leaves .177 the actual Reſiſtance in 4 Inches Depth, *viz.* $(.177 \times 253 =)$ 44 Grains.

But this Reſiſtance will not be the ſame in all Weathers, in order therefore to calculate what it will be when the ☿ of the common Baroſcope is very low: For Example, but 28 Inches high = 392 of Water; f muſt be ſuppoſed = 392, therefore $F = f + b + 1 = 398.3$, and the reſt as before; *viz.* $d = 163$, $fc = 67424$. $Fd = 649229$. thence by the aforeſaid Equation $\left.\begin{array}{l} a = 2.59 \\ \alpha = 2.84 \end{array}\right\}$ therefore $\alpha - a = .25$, which × n gives .50 Cubic Inches, which × 253 = 126 Grains. So that this Baroſcope when the ☿ is loweſt, is more exact than the common 126 Times, ſuppoſing the Body immerſed afreſh when the ☿ is ſo low.

Next while the ☿ is ſo very low, ſuppoſe the Top of the Body depreſs'd 4 Inches under Water; therefore $\varphi = F + 4 = 402.3$, the reſt are as before, *viz.* $fc = 67424$, then α will be 19: but before, while the Top of the Body was at the Surface, α was 2.59; therefore the Difference 69 × Tube's Area 2, gives 1.38 Cube-Inches, which × 253 gives 349 Grains, and ſo much the Baroſcope is heavier, when the Top xm is 4 Inches under Water; or which comes to the ſame, ſuppoſing that ☿ at 28, and xm at the Surface; this Baroſcope by the ☿'s aſcending $\frac{4}{14}$ Inch will become heavier 349 Grains. The Pipe's Capacity in 4 Inches Altitude was 1.457, from which take the aboveſaid 1.38, the Reſidue = .077, which × 253 gives 19 Grains in 4 Inches; ſo that the Pipe will ſuſtain the Baroſcope, and alſo 44 when the ☿ is $30\frac{1}{2}$ high, and but 19 Grains when the ☿ is 28 high. The fewer Grains Difference there are in its ſinking, through 4 Inches, the more nice the Baroſcope will be.

There where the Thread cuts the Surface of the Water, is form'd a Bubble, therefore this Bubble while the Inſtrument ſinks in Water 4 Inches, which is all the room that I give it, the Bubble moves on the 2 Diagonal Threads 20 Inches, it follows therefore that 120 Grains Difference would make the Bubble walk over 120 Inches, if the Threads were ſo long, but as it has been above calculated, about 120 Grains Difference of Weight of the Inſtrument is produc'd by ſo much of the Alteration of the Air, as would make the ☿ of the common Baroſcope $\frac{1}{10}$ Inch; therefore when the ☿ aſcends $\frac{1}{10}$ Inch, the Bubble of this new Baroſcope aſcends 120 Inches; therefore this new Baroſcope is more exact than the common Baroſcope by about 1200 Times.

Obſervations made with this Baroſcope.

1. While the ☿ of the common Baroſcope is often known to be ſtationary 24 Hours together, the Bubble of the new Baroſcope is rarely found to ſtand ſtill one Minute.

2. Suppoſe the Air's Gravity encreaſing, and accordingly the Bubble aſcending, during the Time that it aſcends 20 Inches, it will have many ſhort Deſcents, of the Quantity of ½ Inch 1, 2, 3, or more Inches, each of which being over it will aſcend again. Theſe Retroceſſions are frequent, and of all Varieties in Quantity and Duration, ſo that there is no judging of the general Courſe of the Bubble by bare Inſpection, though you ſee it moving but by waiting a little Time.

3. A ſmall Blaſt of Wind will make the Bubble deſcend; a Blaſt that cannot be heard in a Chamber of the Town, will ſenſibly force the Bubble downward. The Blaſts of Wind ſenſible abroad cauſe many of the aboveſaid Retroceſſions, or Accelerations in the general Courſe; as I found by carrying my Baroſcope to a Place where the Wind was perceptible.

4. Clouds make the Bubble deſcend. A ſmall Cloud approaching to the Zenith, works more than a great Cloud near the Horizon. In cloudy Weather the Bubble deſcending, a Break of the Clouds (or clear Place) approaching to the Zenith, has made the Bubble to aſcend; and after that Break had paſſed beyond the Zenith a conſiderable Space, the Bubble again deſcended.

5. All Clouds (except one) hitherto by me obſerved, have made the Bubble to deſcend. But the other Day the Wind being *North*, and the Courſe of the Bubble deſcending, I ſaw to the Windward a large thick Cloud near the Horizon, and the Bubble ſtill deſcended, but as this Cloud drew near the Zenith, it turned the Way of the Bubble, making it to aſcend, and the Bubble continued aſcending till the Cloud was all paſſed, after which it reſumed its former Deſcent. It was a Cloud that yielded a cold Shower of ſmall Hail.

An Account of a New Thermometer, *by Mr.* Geoffroy. n. 274. p. 961, 962.

IV. This New Thermometer is compos'd of a Bowl or Bottle of Glaſs, *A*, which has no other opening, but by a little Tunnel at the End; and which deſcends almoſt to the Bottom of the Bowl. This Tunnel is open at both Ends *B C*. *B* dips into the Liquor *E*, which is at the Bottom of the Bowl.

The Space of the Bottle of Glaſs is fill'd with Air, which has no Communication with the exterior Air.

Fig. 3.

When the Air contain'd in this Space is rarified by the exterior Air which touches the Bottle, it preſſes at the ſame Time the Liquor *E*, and obliges it to riſe by *B* in the Tunnel *B C*. On the contrary, when it condenſes by the exterior Cold, by not preſſing the Liquor *E*, it permits that which is in the Tunnel to fall.

The Readineſs with which the Air condenſes or rarifies by Cold and Heat, makes the Effects of this Thermometer much more ſudden than thoſe of any other ſort: Beſides, the Effects of this is much greater, the Air being capable of a greater Rarefaction, or of a greater Condenſation, than any other Liquor.

The Cauſe *of the* Variation *of the* Barometer, *&c. by Mr.* J. T. Deſaguliers. n. 351. p. 570.

V. *Remarks on the* Second *Paper in the* Hiſtory *of the* Royal Academy *of* Sciences, *for the Year* 1711, *concerning the* Cauſe *of the* Variation *of the* Barometer: *Shewing that the Way of accounting for it in that Paper is inſufficient, and that the Experiment made uſe of to prove what is there aſſerted, does no Way prove it.*

The Paper is as follows.] “ It appears by the Barometer, that when it “ rains, or a little before the Rain, the Air commonly becomes lighter.

“ That it muſt rain when the Air becomes lighter is eaſy to imagine;
“ for the imperceivable Particles of Water, that ſwim about in the
“ Air in prodigious Quantity, not being ſufficiently ſuſtain'd when the
“ Air has loſt a certain Degree of its Weight, begin to fall, and ſeveral
“ of them joining together in the Fall make Drops of Rain. So when
“ about half of the Air is drawn out of the Recipient of the Air-Pump,
“ (and conſequently the remaining Air is as weak again as at firſt) ſome-
“ thing like a ſmall Rain falls. But why ſhould the Air become lighter?
“ One might imagine that in the Place where it rains, it may have loſt
“ ſome of its Weight and Bulk, by Means of the Winds carrying away
“ ſome Part of it: But Monſieur *Leibnitz*, in a Letter to the Abbot
“ *Bignon*, gives a more ingenious and more new Reaſon for it.

“ He pretends that a Body, which is in a Liquid, weighs with that
“ Liquid, and makes up Part of its whole Weight, ſo long as it is
“ ſuſtained in it; but if it ceaſes to be ſuſtained, and conſequently falls,
“ its Weight no longer makes a Part of the Weight of the Liquid, which
“ thereby comes to weigh leſs. This may naturally be applied to the
“ above-mentioned Particles of Water; they encreaſe the Weight of
“ the Air when it ſuſtains them, which is diminiſhed when it lets them
“ fall: And as it may often happen that the Particles of Water that
“ are higheſt, fall a conſiderable Time before they join with thoſe that
“ are low, the Gravity of the Air diminiſhes before it rains, and the
“ Barometer ſhews it.

“ This new Principle of Monſieur *Leibnitz* is ſurprizing. For muſt
“ not a ſtrange Body, whether ſuſtained in a Liquid or not, always
“ weigh? Can it gravitate upon any other Bottom than that which
“ ſuſtains the whole Liquor? Does that Bottom ceaſe to carry a
“ ſtrange Body, becauſe it falls? And is not that Body all the while it
“ is falling, part of the ſaid Liquid as to the Weight? At that rate, whilſt
“ a Chymical Precipitation is made, the whole Matter ought to weigh
“ leſs, which has never been obſerved, and ſcarce appears credible.

“ Notwithſtanding theſe Objections the Principle holds good, when
“ more cloſely examin'd. What ſuſtains a heavy Body is preſs'd by it.
“ A Table, for example, which ſuſtains a Pound Weight of Iron, is preſs'd
“ by it, and is ſo only becauſe it ſuſtains the whole Action and Effect of
“ the Cauſe of Gravity, (whatever it be) to puſh that Lump of Iron lower.
“ If the Table ſhould yield to the Action of that Cauſe of the Weight
“ (or Gravity) it would not be preſs'd, and therefore would carry no-
“ thing. After the ſame Manner, the Bottom of a Veſſel, which contains
“ a Liquid, oppoſes itſelf to all the Action of the Cauſe of Gravity againſt
“ the ſaid Liquid: If a ſtrange Body ſwims in it, the Bottom oppoſes itſelf
“ alſo to the ſaid Action againſt that Body, which, being *in Æquilibrio* with
“ the Liquid, is in that reſpect really a Part of it. Thus the Bottom is
“ preſs'd both by the Liquid and the ſtrange Body, and ſuſtains them both.
“ But if the Body falls, it yields to the Action of Gravity, and conſe-
“ quently the Bottom does no longer ſuſtain it; neither will it ſuſtain

" it, till the ſaid Body is come down to the Bottom. Therefore during the whole Time of the Fall, the Bottom is eaſed of the Weight " of that Body, which is no longer ſuſtained by any Thing, but puſh'd " down by the Cauſe of Gravity, to which nothing hinders it from " yielding.

" Monſieur *Leibnitz* to confirm his Notion, propoſed an Experiment. He ſays, that two Bodies muſt be tied to the two Ends of " a Thread, the one heavier, and the other lighter than Water, yet " ſuch as both together may ſwim in Water: Put them into a Tube " full of Water, the Tube being tied to one End of the Beam of a " Ballance whoſe other End has a counterpoiſing Weight: Then if we " cut the Thread which ties the Bodies together (that are of unequal " Weight) ſo that the heavieſt may preſently deſcend, he ſays, that " in ſuch a Caſe the Tube would be no longer *in Æquilibrio*, but its " counterpoiſing Weight would preponderate, becauſe the Bottom of " the Tube would be leſs preſs'd. It is plain, that the Tube muſt be " ſufficiently long, that the falling Body may not reach the Bottom " before the Tube has Time to riſe. In Chymical Precipitations, the " Veſſels are either too ſhort, or what is precipitated falls ſometimes " too faſt and ſometimes too ſlow; for then the little Bodies are always " (as to Senſe) *in Æquilibrio* with the Liquor that contains them.

" Monſieur *Ramazzini*, the famous Profeſſor at *Padua*, to whom " Monſieur *Leibnitz* had propoſed his Experiment, has made it with " Succeſs, after ſome fruitleſs Trials. Monſieur *Reaumur* (to whom " the Academy had recommended it) has alſo made it with Succeſs.

Fig. 4. *Remarks upon Monſieur* Leibnitz's *New Principle.*] Let *A B* be the Bottom of a Veſſel full of any Fluid, whoſe Top is either wider than the Bottom as *G H*, narrower as *E F*, or equal to it as *C D*. The Preſſure of the Fluid upon the Baſe *A B* will be equal to the Weight of *C B*, or of a Cylinder or Priſm of the ſame Fluid, made up of the Area of the Baſe multiplied into the perpendicular Height above it.

If the Fluid be equally denſe every way as Water, or of a Denſity uniformly diminiſh'd as you go upwards, this Propoſition (called by Mr. *Boyle* the Hydroſtatical Paradox) will hold good. This is demonſtrated by all Hydroſtatical Writers.

Fig. 5. Let *E F* repreſent Part of the Surface of the Earth, and *G E F H* a Pillar of the Atmoſphere, whoſe Height is *G E* the whole Height of the Air. Let us imagine the Vapours riſing out of the Earth to form themſelves into two Clouds *A* and *B*, and to ſettle in that Place where the Air is of the ſame ſpecific Gravity with themſelves. It is evident that they will cauſe the Air to riſe ſo much higher as their Bulk amounts to, and will therefore make the Surface which was at *G H* to riſe up to *I K*, ſo that the Bottom *E F* which was preſs'd by a Pillar of Air as *G E F H*, is now preſs'd by an higher Pillar as *I E F K*. Now if the Clouds *A*, *B*, by any Cauſe ſoever, change their Place, ſo as to come downwards, (for *Example* to *C*, *D*) the

Height of the Pillar *I E F K* will remain the ſame as it was, and therefore the Bottom *E F* will be preſs'd as before by the foregoing Propoſition.

Corol. 1.] If the Clouds *A B* deſcend, and in their Deſcent keep the ſame Bulk as they had before, the Surface *IK* will remain the ſame, and therefore *E F* will be preſs'd as before.

Corol. 2.] Whether a Body be ſpecifically lighter or ſpecifically heavier than a Fluid; ſo long as it is detain'd in it, it will add to the Fluid as much Weight as the Weight of an equal Bulk of that Fluid: Wherefore a Body does not loſe all that Weight which it added to the whole Weight of the Fluid, when it ceaſes to be ſuſtain'd in the ſaid Fluid; contrary to Monſieur *Leibnitz*'s Principle.

Schol.] If a Cloud (by any Cauſe whatſoever) becomes ſpecifically heavier than that Part of the Air in which it ſwims, the Exceſs of its Gravity above an equal Bulk of Air will make it deſcend, and accelerate its Motion downwards; and then indeed it will loſe of its Weight by the Reſiſtance of the *Medium*, till it comes to an uniform (or ſenſibly uniform) Motion: but all the Weight that it will loſe will only be the Exceſs of its Gravity above that of the Air; for with the reſt of its Weight it will ſtill make up Part of the Weight of the Air.

Experiment 1.] Having with a Weight in the Scale *C* of the Balance *A B* counterpois'd the long Glaſs of Water *E I*, with a Horſe-Hair I let down the leaden Weight *W* into the Water, which from *F G* aroſe up to *E H*; and therefore the Water became heavier by the Weight of a Bulk of Water equal to the Lead. Having with another Weight in *C* made up the Counterpoiſe to the whole, with fine Sciſſars I cut the Thread of the Plummet; and all the while the Plummet was falling, the Water deſcended rather than roſe; and when the Lead was at the Bottom the Water overpois'd, becauſe it had then added to it all the Exceſs of Weight of the Lead above an equal Bulk of Water, which by Experiment is about $\frac{10}{11}$ of its Weight. Had Meſſieurs *Reaumur* and *Ramazzini* tried the Experiment thus, the Succeſs had been the ſame; but M. *Ramazzini* (as I underſtood from a Gentleman who was preſent) tried it in the following Manner, as I have ſince done. Fig. 6.

Experiment 2.] Making uſe of the abovementioned Machine, after I had balanc'd the Water and Lead in it, I fix'd to the End of the Beam *B* the Thread of the Plummet, which in the former Experiment I held in my Hand. This added to the Weight hanging at *B*, and oblig'd me to put into the other Scale a Weight equal to $\frac{10}{11}$ of the Lead, to recover the *Æquilibrium*. Then cutting the Thread or Hair, the Scale with the Weights overpois'd whilſt the Lead was falling; but the *Æquilibrium* was reſtor'd when it came to the Bottom. So that the Lead even then muſt have loſt only its Exceſs of Weight above Water. Fig. 7.

Experiment 3.] I tried the Way propoſed by Monſieur *Leibnitz* in the following Manner.

Fig. 8. I took a Cork *C* weighing an Ounce, and ſomething more than four times lighter than an equal Bulk of Water, and a Ball of Antimony *W* about four times ſpecifically heavier than Water, and of four Ounces Weight. The Cork laid upon the Water in the Veſſel *E A B D* raiſ'd the Water from *S S* to *G G*, and added an Ounce to the Weight of the whole Water: then ſuſpending the Ball of Antimony by a String, and letting it hang in the Water at *N*, it raiſ'd the Water from *G G* to *H H*, and ſo added another Ounce to the Weight of the Water. Then tying the Antimony to the Cork, the Cork had added to it three Fig. 9. Quarters of the Weight of the Antimony which the Hand before had ſuſtain'd, and made it ſink ſo as to be almoſt cover'd, and raiſed the Water to *i k*, adding three Ounces to its Weight. Hanging this Veſſel of Water upon the Balance, and a Counterpoiſe at the other End, upon cutting the String the Veſſel of Water was raiſ'd up, and the *Æquilibrium* was not reſtor'd till the Antimony came to the Bottom.

By obſerving that as the Cork (being freed from the Weight of the Antimony) aroſe, and that during the Fall of the Body, the Water ſunk to *b b*, it appears that this is, in Effect, the ſame Experiment as the former, and concludes no more. As to the real Cauſe of the Variation of the Barometer, namely, the Accumulation of the Air by Winds over the Place where the Barometer riſes; and Part of the Air being blown away where the Mercury in the Barometer ſinks, ſee Dr. *Halley*'s Account of it in the *Phil. Tranſact.* Num. 181. Vid. Supra. V. II. p. 20.

Poſtſcript.] In making the firſt Experiment before the R. Society, of a Piece of Lead ſuſpended by a Thread, whilſt it was wholly cover'd with Water in the large Tube in which it hung (whoſe Length was four Feet) it was obſervable, not only that the End of the Balance (to which the Tube of Water with the Lead in it was fixed) did not riſe when the Thread was cut, (to let the Lead fall from the Top to the Bottom of the Tube) as it muſt have done according to M. *Leibnitz*'s Principle; but that the ſaid End of the Balance began to deſcend from the Time that the Lead began to fall. Therefore to be ſure that it was not the Plummet's rubbing againſt the Sides of the Tube in its Fall, which cauſed that *Phænomenon*, I hung to the Balance a long Glaſs of three Inches Diameter inſtead of the Tube, and making the Experiment as before, it ſucceeded in the ſame manner: The End of the Balance, which carried the Veſſel of Water, ſunk as ſoon as the Thread of the Plummet was cut; tho' this Glaſs was not above half ſo long as the Tube.

When by holding of the String I drew the Lead upwards and downwards in the Water, there was no ſenſible Alteration of the *Æquilibrium*. Neither was it alter'd by cutting the String of a Stone-Plummet, becauſe of the Shortneſs of the Glaſs, and the little Exceſs of ſpecific Gravity in the Stone: for the greater the Difference is betwixt the Body made uſe of in this Experiment and Water, as well as the bigger the Body itſelf is, the better the Experiment will ſucceed.

Hence it appears, that when a Body, ſpecifically heavier than a Fluid, is (by what Cauſe ſoever) detain'd in any Place of the ſaid Fluid, it adds as much to the Weight of the whole Fluid as an equal Bulk of the ſaid Fluid amounts to: And when the ſaid Body, by the Action of its Exceſs of ſpecific Gravity above the Fluid, deſcends with an accelerated Motion; ſo long as that Motion is accelerated, the Reſiſtance of the Fluid (which is as the Square of the Velocity) takes off ſomething of the whole Weight of the Body; but as much as the Body loſes, ſo much the Water gains, over and above what was given it by its riſing on Account of the immers'd Body.

A Body therefore that falls in a Fluid is ſo far from making the Fluid lighter as it falls, that it makes it preſs more upon the Bottom that ſuſtains it, when it is falling, than when it was at reſt in the Fluid.

If the Veſſel of Water be long enough for the falling Body to come to an uniform Motion before it reaches the Bottom, the Force impreſs'd on the Water under the Body will make it preſs the Bottom, as much as if the Body were actually at Bottom, the Body in that Caſe loſing all its Exceſs of Gravity above that of the Water, and the Water gaining it.

Hence it follows, that a falling Cloud, when it comes to an uniform Motion, will not only add to the Weight of the Air as much as the Weight of an equal Bulk of Air; but even as much as its whole Weight amounts to, tho' it be ſpecifically heavier than the Air about it.

All the Diminution of Weight that can be allow'd in this Caſe is this. If we imagine the Air to have a ſmooth, regular Surface, as we have at firſt ſuppos'd, (or if that not allow'd, we may take any Imaginary Surface of it above the Clouds) when a falling Cloud is diminiſh'd in Bulk, (as when it is chang'd into Rain) the Surface of the Air will ſubſide in Proportion to that Diminution, and therefore will weigh leſs, by ſo much as is the Weight of a Quantity of Air equal to the Bulk that Cloud has loſt: But when the Drops of Rain after Acceleration (occaſion'd by their Exceſs of Gravity above that of the Air) are come to an uniform Motion by the Reſiſtance of the Air, they reſtore to the Air the Weight that it had loſt. Now this uniform Motion being acquir'd in about two Seconds of Time, and the Diminution of Gravity in the Air being inſenſible, when compared to near three Inches of Mercury (for ſuch is the Variation of the Barometer with us) can no way be the Occaſion of thoſe ſo ſenſible Alterations in it, which happen ſome time before Rain or Fair Weather.

'*Add to this, that the whole Quantity of Rain that falls in* England *and* France, *in the Space of one Year, ſcarce ever equals two Inches of* Mercury: *And in moſt Places between the* Tropicks, *the Rains fall, at certain Seaſons, in very great Quantities, and yet the* Barometer *ſhews there very little or no Alteration.*

Experiments made with the Barometer, *by Dr.* J. Scheuchzer. n. 344. p. 266.

VI. Theſe Barometrical Experiments, for inquiring into the different Elaſticity of different Kinds of Air, were made by help of a Tube 32 Digits long, *Paris* Meaſure, and 2 Lines Diameter, in different Parts of *Switzerland*, on occaſion of an Excurſion upon the *Alps*, undertaken in *September* 1714.

The firſt Column ſhews the Air left in the Tube. The ſecond the Height of the Mercury above the Superficies of the Quickſilver. The third the Spaces of the expanded Air. The fourth ſhews the Deſcent of the Mercury becauſe of the Air that is left.

Sept. 6. At *Zurich*, the Height of the whole Barometer at 8 a-Clock before Noon was 26 *Paris* Digits, 4 Lines. But at 9½ it was 26 Dig. 4½ Lines.

Column I.	Column II.		Column III.		Column IV.	
Digits.	Digits.	Lines.	Digits.	Lines.	Digits.	Lines.
3	19	9 Twice.	12	6½ Twice.	6	7½
6	16	8	15	7½	9	8½
....	16	7½	15	8	9	9
9						
12	11	11 Twice.	20	3 Twice.	14	5½
15	9	9 Twice.	22	6 Twice.	16	7½
18	7	5½	24	8½	18	11
	7	6	24	8	18	10½
21	5	3	27	0 Twice.	21	1½
24	3	3	28	11 Twice.	23	1½
27	1	6	30	7½ Twice.	24	10½
30	0	4	31	10½ Twice.	26	0

Sept. 11. in a Plain of the *Alps* call'd **Ennenſewen gen Abeten**, near the Mountain *Liber*, under the Government of *Glarys*, at one in the Afternoon, the Sky being clear, the Altitude of the whole Barometer was 23. 10 Twice.

Column I.	Column II.		Column III.		Column IV.	
Digits.	Digits.	Lines.	Digits.	Lines.	Digits.	Lines.
3	18	7	13	6	5	3
6	15	7½	16	4	8	2½
9	13	3	18	7	10	7
12	11	1½	20	9	12	8½
15	9	0	22	9	14	10
18	6	11	25	0	16	11
21	4	11	26	10	18	11
24	3	0	28	10	20	10
27	1	4	30	5	22	6
30	0	2	31	8	23	8

Sept. 12. At 7 before Noon, the Sky clear, **auff Sattel** an Eminence of the Mountain *Liber*, the Altitude of the whole Barometer was 21. 8.

Column I.	Column II.		Column III.		Column IV.	
Digits.	Digits.	Lines.	Digits.	Lines.	Digits.	Lines.
3	17	6	14	6	4	2
6	14	7	17	3	7	1
9	12	6	19	6	9	2
12	10	5	21	6	11	3
15	8	5	23	6	13	3
18	6	5	25	3	15	3
21	4	7	27	1	17	1
24	2	9½	29	0½	18	10½
27	1	4	30	6	20	4
30	0	2	31	8	21	6

Sept. 12. At 9 before Noon, the Sky clear, **auff dem Blattenſtock**, an Eminence of the Mountain *Liber*, the Altitude of the whole Barometer was 21. 6.

3	17	2½	14	6	4	3½
6	14	5	17	5	7	1
9	12	4	19	6	9	2
12	10	4½	21	5	11	1½
15	8	7	23	4½	12	11
18	6	7	25	3	14	11
21	4	8	27	3	16	10
24	2	9	29	0	18	9
27	1	3	30	5	20	3
30	0	3	31	6	21	3

Sept. 14. At 12 within the Iron Mine at *Saruneta*, about 300 Paces from the Entrance, the Sky without being clear. The Height of the whole Barometer was 24. 4. and 24. 3.

3	18	9	13	1	5	7
6	15	9	16	1	8	7
9	13	5	18	5	10	11
12	11	3	20	7	13	1
15	9	1	22	9	15	3
18	7	0	24	10	17	4
21	4	11	27	0	19	5
24	3	0	28	10	21	4
27	1	4	30	6	23	0
30	0	3	31	6	24	1

Out of this Metallic Mine, in the open Air, I obſerved the ſame Altitude of the Mercury in the whole Barometer, alſo in 3 and 9 Digits of Air that was left in the Tube. But it muſt be obſerved, that in the inmoſt Parts of the Mine, where I made my Experiments, the Air was rarified by means of a Fire lighted the Day before, (with which the Miners mollify the Hardneſs of the Vein,) and the Place was moderately warm'd like a Stove.

N. B: *It is found by many Experiments made before the Royal Society, that the Elaſtic Force of compreſs'd Air is as the compreſſing Weights directly. By theſe Obſervations of the learned* Scheuchzer *it appears, that the ſame Rule obtains very nearly in rarified Air. For though ſome Difference is found, yet it is not ſo great but that it may be owing to the unequal Diameters of the Tube. Now that theſe Experiments may be rightly made, it is neceſſary, that the Capacity of the Tube be divided into equal Parts, by putting the Mercury in by degrees, inſtead of taking Parts equal in Length.*

VII. *Obſervations on the* Weather *in a Voyage to* China, 1709, *by Mr.* J. Cunningham. n. 292. p. 1639.

Weather.	Winds.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon	Needles Variation E. or W.	Longitude E. from St. *Jago*.	Latitude N. or S.	Philoſ. Barom. Altit.	Ther. Altit. below Extream Heat.	Day of the Mon.
Rainy and Cloudy.	Variable Breezes, and 10 Hours calm.	8° 30 N		6° 16 E	1° 26 N		3 Div.	*Jan.* 31.
Rainy and cloudy with Lightning.	N S by W S W by S and 16 Hours calm.			6 11 E	1 18 N		4	*Febr.* 1
Fair.	Variable Breezes and 11 Hours calm.			6 13 E	1 14 N		5	2
Fair with Rain at noon	Variable.			5 57 E	1 07 N		5	3
Fair and cloudy, Rain in the Forenoon.	Variable.			5 49 E	0 27 N		2	4
Rainy and cloudy.	Variable with 9 hours calm.			5 44 E	0 00		4	5
Fair and cloudy with ſome Rain.	Variable with 4 hours calm.			5 35 E	0 30 S		4	6
Fair and cloudy.	Small Gales from E by S to S E by S.	3 30 S		5 08 E	1 46 S		5	7
Fair and pleaſant.	Eaſy Gales from E by S to S E by E.			4 56 E	3 00 S		4½	8
Fair and pleaſant.	Eaſy at E S E, and S E by E.			4 19 E	4 29 S		5	9
Fair and pleaſant.	Eaſy at S E by E and S E.	10 00 S		3 54 E	5 57 S		5	10
Fair and pleaſant.	Fine Gales S E by E.		2° 17 E	3 05 E	7 10 S		6	11
Fair and pleaſant.	E S E fine.		2 20 E	2 22 E	8 46 S		6	12
Fair and pleaſant with one Shower.	E S S and E by S.		2 50 E	1 37 E	10 29 S		8	13
Fair and cloudy with ſome Squalls.	E by S and E.		3 30 E	1 20 E	12 05 S		7	14
Fair, with one Squall.	E by N to E S E.		4 12 E	1 10 E	13 44 S		7½	15
Fair and pleaſant.	E by S and E.	19 00 S	4 10 E	1 10 E	15 09 S		7½	16
Fair and pleaſant.	E.		4 52 E	1 14 E	16 32 S		8	17
Fair and cloudy with one Shower.	E.		5 14 E	1 19 E	18 01 S		8½	18
Fair with one Shower.	E by S to E by N.	30 00 S	5 42 E	1 29 E	19 14 S		7½	19
Fair and cloudy with ſeveral Squalls.	S E by E to E by N ſmall.		6 18 E	1 15 E	20 05 S		8	20
Fair with 2 Showers.	NNE to E by N eaſy.			1 35 E	21 16 S		7	21

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philof. Barom Altit.	Latitude N. or S.	Longitude E. from St. *Jago*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon		Winds.	Weather.
22	7		22 23 S	1 54 E	7 02 E		dif.	N N E to E by N.	Fair with a Shower.
23	5		23 47 S	2 39 E				N N E to N N W.	Fair and pleaſant.
24	5		25 21 S	3 28 E				N N E to N E by E.	Fair and pleaſant.
25	6½		26 38 S	4 09 E	8 00 E	39 00 S		N E by N to N N E.	Fair and pleaſant.
26	6½		27 49 S	4 52 E				N E by E to N.	Fair and pleaſant.
27	8		29 16 S	6 07 E				N to N W.	Fair ſometimes cloudy
28	8		30 01 S	7 34 E				W N W to W S W.	Cloudy & ſqually with Rain and Lightning.
29	10½		31 26 S	10 20 E				W N W to N by E freſh.	Squally with much Rain & ſome Thunder
March 1.	12½	8	31 10 S	11 49 E				N W to W moderate.	Uncertain with Thunder and Rain.
2	13	10	31 16 S	13 57 E	4 50 E	42 00 S		W to N W moderate.	Fair and cloudy.
3	17½	14	31 13 S	16 04 E				W to S freſh.	Cloudy and ſqually.
4	23½	18	30 26 S	17 51 E				S by E to S E by E.	Squally and cloudy.
5	26	19½	30 58 S	17 17 E				E S E and E by S.	Fair and cloudy.
6	24	20	32 07 S	17 08 E	3 05 E			E by S to E by N moderate.	Fair and cloudy.
7	23	26	33 06 S	16 54 E				E by N to S E by E ſmall.	Fair and cloudy.
8	32	32	33 14 S	18 26 E	2 05 E			S E to S S W moderate.	Fair and cloudy.
9	33	38½	32 45 S	19 59 E				S to S S W blowing hard.	Cloſe and ſqually.
10	29	34	32 27 S	21 13 E				S by E & S moderate.	Gray and cloudy.
11	29	32½	32 01 S	22 32 E				S by E to S E by E.	Squally, cloſe and cloudy.
12	28½	33½	32 36 S	12 23 E				S S E to E by S.	Dry, cloſe & cloudy
13	27	34	33 42 S	22 42 E				E by S to E by N eaſy.	Fair and cloſe.
14	26	31	34 08 S	23 23 E	1 15 E			Variable and ſmall.	Fair and cloſe.
15	26	30	34 19 S	25 26 E	0 57 E			N to N W by N eaſy.	Fair and ſerene.
16	24	30	34 46 S	27 45 E	0 20 E			N by W to N N E.	Fair and ſerene, ſometimes cloſe.
17	25	30	34 55 S	29 48 E	0 22 W			N by E to N N W a fine Gale.	Fair and ſerene.
18	25½	30	34 59 S	33 27 E	1 19 W	47 00 S		N to N N W.	Fair and ſerene, this Forenoon cloudy.
19	34	38	34 44 S	36 25 E				N N W to S W and S by W.	Thick and ſqually, this Forenoon fair.
20	26	31½	34 22 S	37 45 E	6 25 W			S W to N W eaſy.	Fair and cloudy.
21	28	33	34 29 S	39 04 E				N W by N to W eaſy.	Fair and cloudy.
22	37	42	34 08 S	41 31 E				W to S S E fine.	Fair and ſometimes ſqually.
23	30	36	34 35 S	43 41 E	7 05 W			S to W S W fine.	Variable Weather.
24	26½	32	34 08 S	45 06 E	8 80 W			S S W to W S W ſmall.	Fair and pleaſant.
25		30½	33 58 S	47 02 E	8 52 W			S W by S to S E by S eaſy.	Variable.

Weather

Weather.	Winds.	Needles Inclin. or Depreſ. of the N. or S. Po. under the Horizon.	Needles Variation E. or W.	Longitude E. from St. *Jago*.	Latitude N. or S.	Philoſ. Barom Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and cloudy.	S E by S to S by W moderate.		9 43 W	48 32 E	33 35 S	26½	25½	26
Variable.	S W by S to S moderate.		10 39 W	49 56 E	33 51 S	29	27	27
Fine moderate Weather.	S W by S to S by W ſmall.			50 36 E	34 03 S	30½	35½	28
Fair and pleaſant.	S E ſmall, ſometimes freſh.			50 36 E	34 03 S	34½	33	29
Fair and pleaſant.	SW to SE moſt Part calm.	48 00 S		50 36 E	34 03 S	31	30	30
Fair and pleaſant.	Variable Breezes and calm.			50 36 E	34 03 S	25	26	31
The ſame.	S to S E ſmall.			At the	Cape			*Apr.* 1.
The ſame.	S E ſmall.			of				2
The ſame.	S E and S E by S moderate.			*Good-*	*Hope*.			3
The ſame.	S E and S S E ſmall and calm.							4
The ſame.	S E by S ſmall, at Night freſh.							5
The ſame.	S E ſmall.							6
The ſame.	Variable and calm.							7
The forenoon foggy, Afternoon clear'd up.	Calm, at Night blowing freſh.					34	30½	8
Fair and hazy.	S S E and S by E blowing hard.			Longit. from the				9
Fair and pleaſant.	S S E fine Gales.			Cape of *Good Hope*				10
Fair and gray.	S E by S to N E moderate.			00 43 W	34 45 S	29	31	11
Fair and cloudy.	Variable and ſmall.		11 29 W	00 25 W	35 01 S	28	26	12
Squally.	S S E to S E by E moderate.			00 08 W	35 30 S	42½	33	13
Variable.	S E to E by N.			00 36 W	36 52 S	44½	34½	14
Fair and cloudy.	E to E N E ſmall.			00 13 W	37 51 S	29	25½	15
Variable.	S by E to S W by S ſmall, ſometimes calm.		12 40 W	1 03 E	37 57 S	31½	27	16
Variable.	S S W to E S E.			2 38 E	37 41 S			17
Fair and cloſe.	E by S to E N E ſmall.			3 29 E	38 45 S	38	31	18
Fair and cloudy.	E by S to N E by N moderate.			4 50 E	39 53 S	34	26	19
Cloudy and overcaſt.	N E by E to E by S moderate.			5 58 E	40 42 S	39	31	20
Moderate Weather.	N E by E to N E by N eaſy.			7 49 E	41 06 S	34	32½	21
Variable.	W S W to S E freſh.			10 06 E	39 52 S	45½	40	22
Fair and cloudy.	S E to S S E ſmall.		19 06 W	11 34 E	38 51 S	44	38	23
Fair and pleaſant.	S E to N N E ſmall.			11 50 E	39 09 S	33½	32	24

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Baro. Altit.	Latitude N. or S.	Longitude E. from the Cape of *Good-Hope*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon	dif.	Winds.	Weather.
26	46	55	38 00 S	17 06 E				W by N to S W blowing hard.	Variable with Rain and Hail.
27	36	45	37 41 S	19 10 E		60 00 S	8	S W by S to W N W freſh.	Cloſe and cloudy.
28	31	37	37 45 S	21 35 E	21 23 W			W N W to N W by N moderate.	Fair ſomewhat cloudy
29	25	36	37 27 S	23 32 E				N W to S W eaſie.	Variable.
30	23	33	37 30 S	23 57 E	22 27 W			W S W to S E by S ſmall.	Cloſe Weather.
May 1.	33	42	37 58 S	25 24 E				N N E to E ſmall.	Cloſe and cloudy.
2	32	45	38 16 S	27 00 E	24 30 W			N E by E to N by E eaſie.	Cloſe.
3	32	40	38 47 S	29 40 E				N E by N to N N W freſh.	Cloſe and ſqually.
4	30	31½	38 50 S	33 20 E				N N W to N W freſh.	Fair and cloudy.
5	37	37	38 43 S	36 20 E		60 00 S	7	N W to S W freſh.	Variable and ſqually.
6	38½	45½	38 35 S	39 54 E				N W to S W eaſie.	Variable and ſqually.
7	38½	45½	38 17 S	42 07 E		69 00 S	8	W N W to S W moderate.	Fair Weather.
8	46½	53	37 49 S	45 51 E	24 20 W			W N W to S W by W freſh.	Variable.
9	35	40	38 48 S	49 19 E				W S W and W N W freſh.	Variable.
10	32	39	38 30 S	52 41 E	24 00 W	72 00 S	8	W by N to N W by W freſh.	Variable.
11	35	16	38 09 S	56 08 E				W N W and W freſh.	Moderate with ſome Rain.
12	32	42	37 25 S	58 16 E				W to S W eaſie.	The ſame.
13	33½	47½	37 25 S	59 11 E	20 48 W			S W to N N E ſmall	Cloudy Weather.
14	34	45½	37 10 S	60 54 E	20 00 W	75 00 S	8	W N W to N W by N ſmall.	Fair and pleaſant.
15	30	38½	37 13 S	63 29 E	19 00 W			W N W to S W fine Gales.	Variable.
16	34	41	36 53 S	65 04 E	18 43 W	70 00 S	6	S W to W N W eaſie.	Cloſe and hazy with Rain.
17	31½	36½	36 48 S	68 14 E	17 40 W			W N W to N W freſh.	Variable.
18	35	1	36 56 S	71 12 E		68 00 S	8	W N W and W by N fine.	Fair and cloudy.
19	35½	41	36 00 S	74 16 E				W N W and W freſh.	Moderate.
20	32	34	35 01 S	76 39 E				N W by W to W fine.	The ſame.
21	32½	37	34 07 S	78 32 E	14 28 W	68 00 S	8	W by S to N W by N	The ſame.
22	27	25½	33 07 S	81 05 E	14 00 W			N W by N and N W	The ſame.
23	28½	24½	32 53 S	83 38 E	3 3 W			N W by N to N E	Variable.
24	35	33	31 35 S	85 13 E				N by E to W by S	Thick and ſqually.
25	29½	30½	30 11 S	86 28 E		68 00 S	8	S W to W N W	Variable.
26	31	34½	29 21 S	87 06 E	10 04 W			SW by W & SW by S	Fair and pleaſant.

Weather.	Winds.		Needles Inclin. or Depreſſion of the N. or S Point under the Horizon	Needles Variation E. or W.	Longitude E. from the Cape of *Good-Hope.*	Latitude N. or S.	Philoſ. Baro. Altit.	Ther. Altit. below Extream Heat.	Day of the Mon.
		dif.							
The ſame.	S W to S E ſmall.				87 59 E	28 01 S	35	31	27
Variable.	S E. and S E by E.			3 58 W	89 24 E	25 55 S	33	30	28
Squally & Rainy with Thunder & Lightning	S E by E to S S E.				90 29 E	23 59 S	20	27	29
Variable.	S E and S E by E.	8	62 00 S	3 12 W	91 32 E	22 49 S	24	25	30
Fair and ſerene.	S E to S S E.			7 00 W	92 42 E	21 23 S	22	22	31
Fair and pleaſant.	S E and S E by E.			6 35 W	93 20 E	19 54 S	19	19	*June* 1
The ſame.	S E by E and E S E.				94 10 E	18 02 S	17	17	2
The ſame	S E by E and E S E.			4 40 W	94 55 E	16 30 S	13	14	3
The ſame.	E by S to E by N.	7	53 00 S	4 50 W	95 15 E	15 02 S	10	12	4
The ſame.	E by N to E by S.			5 12 W	95 34 E	13 40 S	7	7½	5
The ſame.	E to N E by E.	4	52 00 S	5 20 W	95 42 E	13 01 S	3	5	6
The ſame.	E by N to E S E.			5 15 W	95 56 E	12 59 S	3	5	7
The ſame.	E by N to S E.			4 42 W	96 17 E	12 26 S	3	5	8
The ſame.	E S E to E N E.			4 26 W	96 28 E	11 43 S	1	5½	9
The ſame.	E by N and E.			3 52 W	96 34 E	11 10 S	1	5	10
The ſame.	E by N to E S E.			3 32 W	96 54 E	10 18 S	0	4	11
The ſame.	E by S to E S E.	6	46 00 S	3 26 W	97 37 E	8 45 S	1	5	12
The ſame.	E by S to N N E.			3 12 W	97 21 E	7 52 S	1	5½	13
The ſame.	E S E to N N E.				95 56 E	7 23 S	0	4½	14
The ſame.	S S E to S E.				95 16 E	6 45 S	0	5	15
The ſame.	S S E, S S W and calm.				Betwixt		0	4	16
The ſame.	S S W, S E and calm.				*Java Head*		0	2½	17
The ſame.	S E and E. by S.				and		0	2	18
The ſame.	E N E and S E.				*Batavia*		0	2	19
The ſame.	N E by E to S S E.						0	1	20
The ſame.	N N E to S.	3	40 00 S		Longit. from *Batavia*		0	1	21
The ſame.	N to S S E.				00 05 W		0	1½	22
The ſame.	N W by W and S W.				00 47 E	5 27 S	0	4½	23
Cloudy with ſome Rain.	S by W and S E by E.				1 48 E	5 24 S	0	2	24
Squally with Thunder Lightning and Rain.	E S E to N by E.				1 55 E	5 51 S	0	3	25
Cloudy with Rain.	E S E to N E by E.	4	38 00 S		1 51 E	6 12 S	2½	6½	26
The ſame.	Calm				1 59 E	6 16 S	0	5	27
Variable.	E by N to E S E ſmall.				2 02 E	6 29 S	0	5	28
Fair.	E S E and S E ſmall.				2 18 E	6 21 S	0	5	29
Uncertain.	Variable Breezes.				2 33 E	6 29 S	0	5	30
Fair with ſome Rain.	E by S to N E by E				2 43 E	6 44 S	0	4	*July* 1.
Fair with ſome Rain.	N E by E to S E by E.				2 55 E	6 39 S	0	4½	2
Fair and ſerene.	N E by E to S E by E.				3 34 E	6 35 S	0	3½	3
The ſame.	N E to S S E.				3 49 E	6 30 S	0	3½	4
The ſame.	N E by N to S E.	8	45 00 S		3 49 E	6 35 S	0	5	5

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Barom. Altit.	Latitude N. or S.	Longitude E. from *Batavia*.	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon		Winds.	Weather.
6	8	2	6 12 S	4 07 E			dif.	S E ſmall.	The ſame.
7	6	0	6 21 S	4 28 E				S E by S to E.	The ſame.
8	6	0	6 22 S	4 43 E				S E by E to E N E	The ſame.
9	6	1	6 28 S	5 13 E				E by S to E by N.	The ſame.
10	8½	3	6 50 S	5 37 E	1 25 W	41 10 S	2	S E by E to E by N.	The ſame.
11	6	0	6 44 S	5 47 E				E N E to S S E.	The ſame, with ſome Rain.
12	5	½	6 23 S	6 05 E				E by N to S E.	Fair and ſerene.
13	5	0	6 05 S	6 17 E				S E to E by S.	The ſame.
14	6	2	5 10 S	6 54 E				S E to E S E.	The ſame, with ſome Rain.
15	4	0	4 20 S	7 09 E				S E by S to E S E.	Fair and cloudy.
16	5	0	4 08 S	7 27 E				S E by E to N E by E.	Fair and ſerene.
17	5	0	4 00 S	7 30 E	At the *Banjar*	Bar of on *Borneo*		E to S E and calm.	Fair and cloudy.
18	8	4	4 00 S	7 30 E				E to S E by S ſmall.	Cloſe and cloudy with Rain.
19	7½	1	4 00 S	7 30 E				S E freſh.	Cloſe and clearing up.
20	6	0	4 15 S	7 06 E		40 00 S	0	S S E to S E	Fair and ſerene.
21	5	0	4 51 S	5 08 E				S E by S and S E.	Fair and cloudy.
22	2½	0	4 59 S	3 12 E				S E by E to E by S.	The ſame.
23	4	0	4 45 S	1 25 E				S by E to E by S.	Cloſe with ſome Rain.
24	7	4	4 09 S	0 17 E				Variable.	Squally with Thunder
25	5	0	4 01 S	0 13 E		35 00 S	6	S to E by S.	Fair and cloſe with Lightning.
26	1½	0	3 32 S					E by S to S E by S.	Fair and ſerene.
27	3	0	In the	Streights				E N E to S by E.	Variable.
28	5	0	of	*Banca*.				S E by S to S.	Fair and ſerene.
29	4½	0	1 59 S					S E by E to S.	The ſame.
30	4	0	0 31 S	Longit.	1 50 W			S E to N N E	The ſame.
31	4	0	1 25 N	from *Pulo*	*Condore*.	31 00 S	5	S S E to S E by S.	The ſame.
Aug. 1	2½	0	3 19 N	1 36 W				S S E to S by W.	Fair and cloſe.
2	1	0	5 07 N	0 52 W				S by W to S E.	Variable with Thunder and Lightning.
3	1	0	6 04 N	0 25 W				Variable.	Fair and cloſe.
4	1	0	7 47 N	0 08 E				S S W to S W by S.	Fair and pleaſant.
5	3½	0	9 16 N	1 25 E				W to S W.	Fair, cloſe and hazy.
6	2	0	10 14 N	3 07 E				S W by W to W.	Fair and hazy.
7	1	0	12 04 N	4 33 E		5 30 S	12	S W by W to S W by S	Fair and ſerene.
8	1	0	24 05 N	5 58 E		4 09 S	13	S W and S W by W.	The ſame.
9	1½	0	16 15 N	7 02 E				W by S to S W by S.	Fair and cloudy.
10	2½	0	18 14 N	7 20 E				Variable.	Squally.
11	1½	0	19 49 N	7 12 E				W S W to W N W. blowing hard.	Squally and much overcaſt.
12	½	0	21 17 N	7 02 E		2 30 S	1	W S W to S S W. moderate.	Fair and cloſe with ſome Rain.

Weather.	Winds.	Needles Inclin. or Depreſ. of the N. or S. Po. under the Horizon.	Needles Variation E. or W.	Longitude from *Pulo Condore*	Latitude N. or S.	Philoſ. Barom Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and ſerene.	S S W to S E by S ſmall.	dif.		7 36 E	21 58 N	above Extr.	1½ Heat.	13
Fair and pleaſant with one Shower.	S E to N N E.	2 6 00 N		7 47 E	22 15 N	0	1 below	14
Fair and pleaſant.	E by N to N E by E.			8 09 E	22 18 N	0	1	15
The ſame.	Variable and calm.		1 20 W	8 43 E	22 32 N	0	0	16
Fair, with ſome drizling Rain.	W S W to S W eaſy.			9 48 E	23 10 N	0	½	17
Fair and ſerene.	Variable and ſmall.			10 04 E	23 32 N	0	1½	18
The ſame.	N to N E by N freſh.			10 18 E	23 56 N	0	2½	19
Fair and hazy.	N by E to N E by N			10 28 E	24 12 N	0	4	20
The ſame.	N E by E to N by E.	6 12 00 N		10 43 E	24 22 N	0	1	21
The ſame.	N E to N N E.			11 01 E	24 32 N	0	3	22
Fair and pleaſant.	N E by E to N N E eaſy.			11 15 E	24 47 N	0	4½	23
Variable.	E N E to N E by N freſh.			11 28 E	24 56 N	0	6	24
Fair and pleaſant.	E N E to N by E moderate.			11 38 E	25 09 N	0	5	25
The ſame.	N by E to N E by E.			12 08 E	25 09 N	0	6	26
The ſame.	E N E to N N E.			12 20 E	25 07 N	0	5	27
Variable.	E by N to N N E.			11 50 E	25 29 N	0	5	28
Variable.	N E by E to N.			12 02 E	25 37 N	0	4	29
Cloſe and ſqually.	N by E to N E by E freſh.			11 47 E	25 49 N	0	3½	30
Variable.	N E by N to E by N.			11 53 E	26 02 N	0	2	31
Fair and pleaſant.	N N E to N E by E.			11 56 E	26 05 N	0	2½	*Sep.* 1.
The ſame, with ſome Rain at Night.	N E ſmall.			At *Crocodile* Iſland.				2
Fair and pleaſant.	N N E ſmall.							3
The ſame.	N by E to N E.							4
Fair and cloudy.	N E moderate.							5
The ſame, at Night much Rain.	N E freſh, at Night S W blowing hard.							6
Cloudy with ſome Rain.	N E freſh and moderate.							7
Fair and pleaſant, at Times overcaſt.	N E moderate.							8
Fair and hazy.	N E moderate.			12 38 E	25 44 N	0	3	9
The ſame.	N E by N to N E by E.			12 13 E	26 11 N	0	3½	10
The ſame.	N E to N N E.			12 47 E	26 11 N	0	5	11
Fair and pleaſant.	N E by N to E by S ſmall.			12 37 E	26 22 N	0	4½	12
Fair.	E N E to N E moderate.			12 40 E	26 26 N	0	8½	13
Fair and cloudy.	N N E to E N E.			12 59 E	26 37 N	0	6½	14

Day

Day of the Mon.	Ther. Altit. below Extream Heat.	Philoſ. Barom Altit.	Latitude N. or S.	Longitude E. from *Pulo Condore.*	Needles Variation E. or W.	Needles Inclin. or Depreſſion of the N. or S. Point under the Horizon	Winds.	Weather.
15	5	0	27 05 N	13 11 E		dif-	N E by E to E by N	Fair cloſe and cloudy.
16	7	0	26 55 N	14 01 E			E N E to N by W.	Fair and cloudy.
17	8	0	27 07 N	14 13 E			N to N E by E.	The ſame.
18	10	7½	27 26 N	14 13 E			N E to N by E.	Variable.
19	9	6½	27 42 N	14 02 E			N by E to N E by E.	Fair.
20	7½	4	27 46 N	14 25 E			N E by E to N by E freſh.	Fair and cloudy.
21	12	10	28 03 N	14 25 E			N E to N N E moderate.	Fair and pleaſant.
22	15	12½	27 49 N	15 31 E			N E by N to N by E	Fair with ſome Rain.
23	17	14	27 51 N	15 01 E			N N E to N freſh.	Fair and cloudy.
24	4	13	27 53 N	16 26 E			N by W to N by E ſmall.	Fair and much overcaſt.
25	14	12	28 10 N	15 36 E			N by E to N E by N	Fair and cloſe.
26	13½	13	28 47 N	15 04 E			N by E to E by N.	Variable.
27	14	13	29 06 N	14 49 E		17 30 N 5	N N E to N E by E	Fair and pleaſant.
28	15½	17	28 55 N	15 09 E	100 E		N N E to N E.	Fair and cloudy.
29	15	13	29 02 N	15 09 E			N E by N.	Fair ſometimes cloſe.
30	15	17	29 43 N	15 19 E			Variable from S S E to N W.	Fair pleaſant and cloudy.
Oct. 1.			29 56 N	14 55 E			W N W to N E by E.	Fair and cloſe.
2			29 56 N	14 55 E			N N W and N ſmall.	Thick and foggy with Rain.
3							N N W to N W ſmall.	Variable, Forenoon ſerene.
4							N to N E moderate.	Variable.
5							N N W to N W blowing freſh.	Fair and cloudy.
6							Forenoon calm, Afternoon S E freſh.	Fair and ſerene.
7							N N E to N E.	Cloudy with Rain.
8							N to N N W.	Cloudy and overcaſt
9							N by W to N E.	Cloudy hazy & Rain.
10	20	20	29 56 N	14 55 E			N E to S E moderate	Cloudy and fair.
11	12	16	30 29 N	14 20 E			S E to S W ſmall	Fair and ſerene.
12	17	15	30 25 N	14 20 E	At	*Chuſan.*	S W ſmall.	The ſame.
13	2[illegible]	32					N N E to N E.	Fair and cloudy.
14	24	30	30 25 N	14 20 E	00 56 E	21 00 N	N E moderate.	Fair and cloudy.
15							N ſmall.	Fair and cloudy.
16	25	29					N E to E moderate.	Cloudy with ſome Rain.
17	16	14					S E ſmall.	Thick and hazy with Rain.
18	15	13					S E moderate.	Thick and hazy with much Rain.

Weather.

Weather.	Winds.	Needles Inclin. or Depreſ. of the N. or S. Po- under the Horizon.	Needles Variation E. or W.	Longitude from *Pulo Condore*	Latitude N. or S.	Philoſ. Barom Altitude.	Ther. Altit. below Extream Heat.	Day of the Mon.
Fair and cloudy.	N E ſmall.	dif.				31	23½	19
The ſame.	N N E to E N E.					30	24	20
Cloudy with ſome Rain.	N N E to S E.					29	24	21
Fair and cloudy.	N to N W freſh.					30	25	12
Fair and pleaſant.	N by W to W N W ſmall.					30	26	23
The ſame.	S and S S E ſmall.					32	27¼	24
The ſame.	S E moderate.					28	24	25
The ſame.	SE to S by E moderate					26	22½	26
Cloudy with ſome Rain.	N W to N by W moderate					27	20	27
Thick and hazy with Rain.	N W ſmall, ſometimes freſh.					45	36½	28
The ſame.	N W to N moderate.					58	45	29
Fair and cloudy.	N N W to N by E ſmall.					59	46	30
The ſame.	N W ſmall.					65	47	31

Note 1. That the Altitude of the Spirits in the Thermometer and Philoſophical Barometer was commonly taken at Noon.

Note 2. That the Account of the Winds and Weather at Sea, is from Noon to Noon.

Note 3. That the middle Inclination of the Dipping-Needle is ſet down with the Difference alſo which was made, as either Side of the Compaſs was turn'd Eaſt or Weſt: Which Difference at firſt was not taken Notice of.

From whence this Difference ſhould ariſe, I cannot determine, the Compaſs ſeeming to be juſtly pois'd and equally divided.

For the few Chaſmata in the Columns of the Thermometer and Barometer, there needs no other Apology, than that I was not on Board to take an Account of them my ſelf.

A Regiſter of the Weather, &c. *at* Chuſan *in* China, 1700. *by Mr.* J. Cunningham. n. 292. p. 1648.

VIII. *Note* 1. The Iſland *Chuſan* is in 30° 25′ N. Latitude upon the Coaſt of *China.*

Note 2. That the following Obſervations were of a portable Barometer from *England*; which by a Barometer ſet up here were always $\frac{6}{10}$ of an Inch lower.

Note 3. That the Barometer ſtood about 18 Feet above the *Superficies* of the Sea at high Water.

1. Grey

November 1700.

1. Grey cloudy Weather, very cold and moderate Gales from N W to N.

2. Grey cloudy Weather with moderate Gales from N W to N, and very cold.

3. Grey cloudy Weather, very cold and ſmall Gales from N by W and N N W. At Night little Wind and more ſerene.

4. Grey cloudy Weather, very cold and moderate Gales at N N W and N by W.

5. Fair and ſerene Weather with ſmall Gales from N N W to N. The Air temperate.

6. Fair and pleaſant Weather, with ſmall Gales at N W and N N W.

7. Fair and pleaſant Weather, ſomewhat hazy, and ſmall Gales at N N W. At Night calm.

8. Fair and pleaſant Weather, with ſmall Gales at N. At Night little Wind.

9. Fair and ſerene Weather, with ſmall Gales at N. At Night calm.

10. Very ſerene and warm Weather, with ſmall Gales at N by W. In the Night calm.

11. Dry and ſerene Weather, with ſmall Gales from S E. At Night calm.

12. Dry and ſerene Weather, with ſome ſmall Northerly Breezes. At Night calm.

13. The Morning foggy, all Day ſerene with ſmall Breezes at N N W.

14. The Morning grey and cloudy, toward Noon thick hazy Weather with drizling Rain till 8 at Night. All Day freſh Gales from W by S to N W. At Night leſs Wind and fair.

15. Grey cloudy Weather with moderate Gales from N W to N.

16. Fair and pleaſant Weather with ſmall Gales from N to N by E.

17. Dry and ſerene Weather with ſmall Gales at N N W.

18. Grey cloudy Weather, with moderate Gales from N W. In the Night cold.

19. Dry Weather ſomewhat cloudy, with ſmall Gales from N W to N. Cold at Night.

20. Dry and pleaſant Weather, with ſmall Gales at N N W.

21. Fair and pleaſant Weather, with ſmall Gales from W by S to N W.

22. Fair and pleaſant Weather, ſomewhat hazy with Gales at S E.

23. Fair and pleaſant Weather, the Afternoon overcaſt, with moderate Gales at N W to N.

24. Dry Weather, ſomewhat cloudy, with moderate Gales from W N W to N.

25. Fair and pleaſant Weather, with ſmall Gales from N by W. At Night calm and cold.

26. Fair and pleaſant Weather, with ſmall Breezes at N W, for the moſt part calm. ☿ Altitude 30 $\frac{8}{20}$.

37. Grey cloudy Morning, with ſmall Gales at W N W. ☿ Altitude 30 $\frac{6}{20}$. In the Afternoon fair and pleaſant with ſmall Southerly Breezes. At Night calm.

28. Fair and pleaſant Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$. The Afternoon ſmall Breezes at S W. At Night calm, and the Breezes veering to N, the Air temperate. ☿ 30 $\frac{4}{20}$.

29. Fair and ſerene Weather, with Calms. ☿ 30 $\frac{1}{20}$. In the Afternoon ſmall Gales at S E. At Night grey cloudy Weather, the Gale veering to N. ☿ 30 $\frac{6}{20}$.

30. A grey cloudy Morning, with moderate Gales at N W and W N W. ☿ 30 $\frac{6}{20}$. All Day more ſerene. In the Evening overcaſt, and ſome Rain at 9 of the Night.

December 1700. 1. Grey cloudy Weather all Day and Night with freſh Gales from N to N E. ☿ 30 $\frac{2}{20}$ falling to 30 $\frac{8}{20}$.

3. In the Morning fair and ſerene. ☿ 30 $\frac{1}{20}$. Since overcaſt and grey cloudy Weather, with moderate Gales at N N E and N. In the Evening ſome Drops of Rain, and ſometimes blowing freſh in the Night, and very cold.

4. Grey cloudy Weather, with moderate Gales at N to N W. ☿ 30 $\frac{12}{20}$, at Night falling to 30 $\frac{11}{20}$, then almoſt calm.

5. A grey cloudy Morning, towards Noon more ſerene. ☿ 30 $\frac{11}{20}$. Freſh Gales at N E. In the Evening overcaſt, with ſome Drops of Rain. Little Wind all Night.

6. A grey Morning ſomewhat cloudy, and a ſmall Breeze at N N E. ☿ 30 $\frac{2}{20}$. In the Afternoon overcaſt, with the Wind at S, and ſmall Drops of Rain. The ☿ falling to 30 $\frac{8}{20}$. Some Rain in the Night.

7. Cloſe thick Weather with drizling Rains all Day and Night, and ſmall Winds at N N E and N. ☿ 30 $\frac{7}{20}$.

8. A grey cloudy Morning with ſome drizling Rain, and moderate Gales at N and N by W. ☿ riſing above 30 $\frac{7}{20}$. All Day and Night overcaſt; the ☿ as before.

9. A grey cloudy ſharp Morning, and ſmall Winds at N N W. ☿ 30 $\frac{6}{20}$. Cloudy all Day, and towards Evening cloſe Weather and calm. ☿ 30 $\frac{5}{20}$.

10. Dry Weather ſomewhat grey and cloudy, with ſmall Breezes at N N W. ☿ 30 $\frac{4}{20}$. All Day overcaſt with variable Breezes intermix'd with Calms. ☿ as before.

11. Fair and pleaſant in the Morning, ſince overcaſt with variable Breezes, the ☿ as before.

12. Grey cloudy Weather, in the Forenoon ſmall Gale at S E. ☿ 30 $\frac{5}{20}$. In the Afternoon the Gale freſhning at N W. ☿ 30 $\frac{5}{20}$. With ſome Rain all Night.

13. Grey cloudy Weather, with moderate Gales from N W to N. ☿ 30 $\frac{4}{20}$. Cold all Night.

14. A ſharp Morning and fair pleaſant Weather, with ſmall Gales at N N W and N. ☿ 30 $\frac{6}{20}$. At Night calm. ☿ 30 $\frac{5}{20}$.

15. Fair and pleaſant Weather, with moderate Gales at S E. ☿ 30 $\frac{4}{20}$ falling to 30 $\frac{3}{20}$.

16. The Morning ſomewhat cloudy, with ſmall Gales at S E. ☿ 30 $\frac{3}{20}$. At Noon veer'd to N W, and the Sky overcaſt; at Night ſome Rain, much Wind and Cold.

17. A ſharp Morning and grey cloudy Weather, with moderate Gales from N W to N N W. ☿ 30 $\frac{7}{20}$. All Day overcaſt, at Night little Wind and much Rain.

18. Thick cloſe rainy Weather, all Day and Night, with ſmall Gales at N W.

19. Grey cloudy Weather, with moderate Gales at N W to N. ☿ $\frac{6}{20}$. Some Rain at Night and very cold.

20. Grey cloudy Weather, with moderate Gales at N N W. ☿ 30 $\frac{7}{20}$. At Night little Wind.

21 Grey cloudy Weather and cold, with moderate Gales from N N W to N W. ☿ 30 $\frac{7}{20}$. At Night drizling Rains. ☿ 30 $\frac{6}{20}$.

22. In the Morning cloſe Weather, with drizling Rains and moderate Gales at N W and N N W. ☿ 30 $\frac{6}{20}$. The Afternoon dry, grey and cloudy.

23. A grey cloudy Morning and calm, ☿ 30 $\frac{5}{20}$, towards Noon more ſerene and a ſmall Breeze at E S E. In the Evening overcaſt with ſome Rain and freſh Gales, all Night at N N W.

24. Grey cloudy Weather, ſomewhat cloſe, with freſh Gales from N N W to N W by W.

25. Grey cloudy Weather, with moderate Gales at N W.

26. Cloſe Weather with drizling Rains, and ſmall Breezes at N E, for the moſt calm. In the Night the Gale freſhned at N. ☿ 30 $\frac{6}{20}$.

27. The Forenoon grey cloudy Weather, and ſmall Gales at N N E. ☿ 30 $\frac{7}{20}$. The Afternoon and all Night cloſe Weather with drizling Rains, the Breeze veering to E N E.

28. Grey cloudy Weather with ſome drizling Rains, and ſmall northerly Gales. ☿ 30 $\frac{7}{20}$.

29. In the Morning ſomewhat fair, then overcaſt with drizling Rains and cloſe Weather all Day and Night, ſmall Gales from N N E to N E. ☿ 30 $\frac{6}{20}$.

30. A grey cloudy Morning, with Gales at E N E. ☿ 30 $\frac{7}{20}$. All Day the foreſaid Weather.

31. In the Morning fair and pleaſant, with ſmall Gales at S E. ☿ 30 $\frac{4}{20}$. In the Forenoon overcaſt, ☿ falling to 30 $\frac{1}{20}$. The Afternoon and Night cloſe thick foggy Weather, with ſome drizling Rain and calm.

January, 1701.

1. Dry Weather, ſomewhat cloſe, with ſmall Gales at S E. ☿ 30 $\frac{1}{20}$. The Afternoon overcaſt and cloſe Weather, with ſmall Gales at E S E. ☿ falling to 29 $\frac{18}{20}$, and much Rain in the Night.

2. Cloſe Weather and drizling Rains, with moderate Gales at N N E. ☿ 30 $\frac{1}{20}$. At Night blowing freſh, ☿ riſing to 30 $\frac{1}{20}$.

3. Cloſe and cloudy Weather, with drizling Rain, and moderate Gales at N. ☿ 30 $\frac{5}{20}$.

4. A grey cloudy Morning, with moderate Gales at N E. ☿ 30 $\frac{1}{20}$. Afternoon cloſe and thick Weather, with drizling Rains. ☿ 30. Much Rain in the Night.

5. Thick cloſe rainy Weather, with moderate Gales at N E. ☿ 30 $\frac{1}{20}$. At Night fair and cold.

6. A grey cloudy Morning, with freſh Gales at N E. ☿ 30 $\frac{6}{20}$. At Noon 30 $\frac{7}{20}$. At Night 30 $\frac{6}{20}$, and ſome Rain.

7. Cloſe and cloudy Weather, in the Morning. ☿ 30 $\frac{5}{20}$. Towards Noon drizling Rains, and encreaſing in the Afternoon, with ſmall Winds at N E. ☿ 30 $\frac{8}{20}$.

8. Thick cloſe and cloudy Weather, with drizling Rains and ſmall Gales at N E. ☿ 30 $\frac{3}{20}$.

9. Cloſe and cloudy Weather, with drizling Rains and ſmall Gales at E S E. ☿ 30 $\frac{4}{20}$. At Night fair. ☿ 30 $\frac{6}{20}$.

10. A grey cloudy Morning with freſh Gales at N. ☿ 30 $\frac{7}{20}$. In the Evening and all Night rainy Weather.

11. A cloſe and cloudy Morning with drizling Rains and ſmall Gales at N. ☿ 30 $\frac{5}{20}$. All Day the aforeſaid Weather.

12. Thick cloſe rainy Weather all Day and Night, with moderate Gales at N N W. ☿ 30 $\frac{2}{20}$. Much Rain at Night.

13. Very thick cloſe rainy Weather, with freſh Gales at N W. ☿ 30. In the Night cold.

14. A ſharp cold Morning, with much Snow falling and cloſe Weather, with freſh Gales at N W. ☿ 30 $\frac{2}{20}$. Continu'd Snowing a little all Day and Night following. ☿ 30 $\frac{1}{20}$.

15. Fair Weather, freezing hard, with ſome Sun-ſhining and freſh Gales at N N W and N by W. ☿ 30 $\frac{5}{20}$.

16. Fair and ſerene Weather all Day and Night, freezing hard, with moderate Gales at N N W. ☿ 30 $\frac{7}{20}$. The Sun melting the Snow.

17. Fair and ſerene Weather, (the Sun diſſolving moſt of the Snow) with freſh Gales at N by W. ☿ 30 $\frac{9}{20}$. At Night ſomewhat cold, freezing hard.

18. Grey cloudy Weather, freezing hard, with moderate Gales at N by W. ☿ $30\frac{11}{20}$. At Night riſing to $30\frac{12}{20}$.

19. Grey cloudy Weather, with little Froſt, and moderate Gales at N N W. ☿ $30\frac{10}{20}$.

20. Grey cloudy Weather, ſomewhat cloſe, with moderate Gales at N N W. ☿ $30\frac{9}{20}$, freezing in the Morning, and inclining to thaw at Night.

21. In the Morning ſomewhat ſerene, the reſt of the Day overcaſt, with moderate Gales at N W, and ſome Thaw. ☿ $29\frac{2}{20}$.

22. Fair and ſerene Weather, with ſmall Gales at W N W. ☿ $30\frac{7}{20}$. thawing all Day with the Heat of the Sun, at Night cold, but not freezing. ☿ as before.

23. Grey and cloudy Weather, with ſmall Gales at S E, thawing a little. ☿ $30\frac{5}{20}$. At Night much Rain and calm. ☿ $30\frac{4}{20}$.

24. A fair and ſerene Morning with ſmall Gales at N N W and N. ☿ $30\frac{4}{20}$. All Day overcaſt, and drizling Rains all Night.

25. Cloſe hazy Weather, with drizling Rain and no Wind. ☿ $30\frac{4}{20}$. At Night much Rain.

26. Very cloſe hazy Weather, with drizling Rains and ſmall Breezes at S E. ☿ $30\frac{2}{20}$. In the Afternoon falling to $29\frac{18}{20}$, at Night much Rain, the Wind veering to N N W. blowing ſometimes in Guſts.

27. Cloſe Weather, with drizling Rains and moderate Gales at N W. ☿ $30\frac{2}{20}$. In the Afternoon fair, and at Night freezing.

28. Grey cloudy Weather, freezing hard all Day, with moderate Gales from N W to N. ☿ $30\frac{4}{20}$. *This Day being New Moon, begun the* Chineſe *New Year.*

29. Fair and ſerene froſty Weather, with moderate Gales at N by W. ☿ $30\frac{6}{20}$.

30. The Morning fair and ſerene, all Day overcaſt with moderate Gales at N to N W. ☿ $30\frac{7}{20}$. Froſty Weather.

31. Fair and ſerene Weather, freezing hard, with moderate Gales at W N W. ☿ $30\frac{7}{20}$.

February.

1. Fair and pleaſant Weather, with ſmall Gales from W, veering to S S E, and at Night to N N W, but no Froſt. ☿ $30\frac{6}{20}$.

2. Fair and pleaſant Weather, in the Morning, little Wind, in the Forenoon fine Gales at N W. ☿ $30\frac{8}{20}$. At Night little Wind.

3. Dry Weather, ſomewhat overcaſt, with ſmall Gales at N W. ☿ $30\frac{6}{20}$. At Night little Wind.

4. Dry Weather, ſomewhat cloſe, with ſmall Gales at S E. ☿ $30\frac{6}{20}$.

5. Fair and cloudy Weather, with ſmall Gales at N W. ☿ $30\frac{4}{20}$.

6. The Morning cloſe and overcaſt, the Afternoon ſerene, with ſmall Gales at N W. ☿ $30\frac{5}{20}$.

7. Fair and cloudy Weather, with ſmall Gales at N N W. ☿ $30\frac{6}{20}$.

8. Fair Weather, ſomewhat cloudy, with variable Breezes round the Compaſs. ☿ $30\frac{6}{20}$.

9. Fair and pleaſant Weather, with ſmall Breezes at S E. ☿ $30\frac{7}{20}$. At Night little Wind from N N W.

10. Cloudy Weather, with moderate Gales at N by W, in the Afternoon and all Night drizling Rains. ☿ $30\frac{4}{20}$.

11. Cloſe Weather, with drizling Rains and ſmall Gales at N by W. ☿ $30\frac{1}{20}$. All Night much Rain.

12. Cloſe Weather, with ſome drizling Rains and ſmall Gales at N by W, and N N W. ☿ $30\frac{2}{20}$.

13. Fair and pleaſant Weather, with ſmall Gales from N to S S E. ☿ $30\frac{5}{20}$.

14. Cloſe and cloudy Weather, with drizling Rains, and ſmall Gales at N N W. ☿ $30\frac{1}{20}$. Afternoon and Night fair, pleaſant and calm. ☿ as before.

15. Fair and ſerene Weather, and no Wind. ☿ $30\frac{2}{20}$. The Afternoon overcaſt, with cloſe Weather, and moderate Gales at S E, and ſome Rain. ☿ 30.

16. Cloudy Weather and ſomewhat cloſe, with ſmall Gales at N N W. ☿ $29\frac{18}{20}$. In the Night freſher Gales.

17. Grey cloudy Weather with moderate Gales at N N E. ☿ $30\frac{3}{20}$.

18. Grey cloudy Weather, with moderate Gales at N. ☿ $30\frac{4}{20}$.

19. Grey cloudy Weather, with moderate Gales at N N W. ☿ $30\frac{4}{20}$.

20. Grey cloudy Weather, with ſmall Gales at N by W. ☿ $30\frac{6}{20}$, Very cold with ſome Snow at Night.

21. Grey cloudy Weather, with ſmall Gales at N. ☿ $30\frac{8}{20}$. Some Snow this Morning, whitening the Tops of the Hills and lying all Day.

22. In the Morning ſome Sun-ſhining diſſolving the Snow; all Day grey cloudy Weather, and temperate with ſmall Gales at N N W. ☿ $30\frac{8}{20}$.

23. Dry Weather, ſomewhat cloudy, calm in the Morning, at Noon blowing freſh from N W till Night, then little Wind. ☿ $30\frac{6}{20}$.

24. Fair and pleaſant, with ſmall Gales at S E, the Afternoon calm, at Night moderate Gales from N N W. ☿ $30\frac{6}{20}$.

25. Fair and pleaſant, with moderate Gales at S S E and S E. ☿ $30\frac{6}{20}$.

26. Grey cloudy Weather, with drizling Rains all Day and Night, and moderate Gales at S E. ☿ $30\frac{6}{20}$.

27. Fair Weather, clearing up with ſmall Gales at S E.

28. Fair and pleaſant Weather, with ſmall Gales N W. In the Afternoon veering to W S W, and about to S E. ☿ $30\frac{6}{20}$.

1. Dry Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ $30\frac{3}{20}$. *March.*

2. The Morning fair and very ſerene, the Afternoon overcaſt with ſmall Gales at S E. ☿ $30\frac{6}{20}$.

3. The Morning fair and ſerene, the Afternoon overcaſt with moderate Gales at E S E and S E. ☿ $30\frac{8}{20}$.

4. Grey cloudy Weather with moderate Gales at S E. At Night blowing freſh from N E. ☿ $30\frac{4}{20}$.

5. Grey cloudy Weather, with ſome Rain, and moderate Gales at S E. At Night ſome Thunder, Lightning and Rain. ☿ below 30.

6. The Morning ſerene and temperately warm, with ſmall Southwardly Breezes. The Forenoon and all Day overcaſt, in the Afternoon ſome Rain, cloſe hazy Weather with ſmall Gales at N by E and N. ☿ 30.

7. Grey cloudy Weather, with ſmall Gales at E S E. At Night much Rain. ☿ 30.

8. Grey cloudy Weather, ſomewhat hazy, with moderate Gales at N and N by E. ☿ $30\frac{4}{20}$.

9. Fair and pleaſant Weather in the Forenoon, with ſmall Gales at S E. ☿ $30\frac{6}{20}$. The Afternoon overcaſt, and little Wind all Night. ☿ $30\frac{5}{20}$.

10. Dry Weather, ſomewhat cloſe, with ſmall Gales at S E, in the Evening ſome Rain. ☿ $30\frac{4}{20}$. In the Night much Wind and Rain.

11. Cloſe and cloudy Weather, with ſmall Rains and moderate Gales at N N W. ☿ $30\frac{4}{20}$.

12. Cloſe and cloudy Weather, with moderate Gales from S E to N E. ☿ $30\frac{4}{20}$.

13. Grey cloudy and cloſe Weather, with ſome Rain and ſmall Gales at S E. ☿ 30.

14. Grey cloudy and cloſe Weather, with ſmall Gales variable from S E to N W. ☿ $30\frac{3}{20}$.

15. Very cloſe hazy Weather, calm all Day. ☿ $29\frac{17}{20}$. At Night ſmall Gales at W N W with ſome Rain.

16. Cloſe and cloudy Weather, with ſmall Gales from N W to N. ☿ 30.

17. Fair and ſerene Weather, with ſmall variable Gales. ☿ $30\frac{4}{20}$.

18. In the Morning overcaſt with moderate Gales at N W, preſently veering to S E, with drizling Rains all Day. ☿ $30\frac{3}{20}$, falling to $29\frac{17}{20}$.

19. Grey cloudy Weather, for the moſt part calm. ☿ $29\frac{17}{20}$.

20. Very thick foggy Weather all Day, with ſmall variable Breezes, for the moſt part calm. ☿ $29\frac{17}{20}$.

21. In the Morning foggy, the reſt fair and ſerene Weather, with ſmall Southwardly Gales. ☿ $29\frac{18}{20}$.

22. The Morning fair and ſerene, the Afternoon overcaſt with ſome Rain and variable Gales. ☿ 30.

23. Grey cloudy Weather, the Afternoon and all Night drizling Rains and moderate Gales at N N E. ☿ 30.

24. Cloſe Weather with continu'd drizling Rains, and at Night much Rain with moderate Gales from N N E to N, and very cold. ☿ $30\frac{1}{20}$.

25. The Morning ſomewhat cloudy, the Afternoon ſerene, with moderate Gales at N. ☿ $30\frac{3}{20}$.

26. Dry Weather, ſomewhat cloudy, with ſmall variable Gales. ☿ $30\frac{4}{20}$.

27. Grey cloudy Weather, with ſmall variable Gales, ſometimes calm. ☿ $30\frac{2}{20}$.

28. Cloſe hazy Weather, with ſome Rain and ſmall variable Gales, ſometimes calm. ☿ $29\frac{18}{20}$.

29. The Forenoon grey cloudy Weather, the Afternoon very cloſe and hazy with much Rain. ☿ $29\frac{17}{20}$. Small variable Breezes, for the moſt part calm.

30. Cloſe and cloudy Weather, with moderate Gales at N N E. ☿ $29\frac{18}{20}$. At Night riſing to 30, and the Gale freſhning.

31. Fair Weather, ſomewhat cloudy, with ſmall variable Gales. ☿ 30.

April. 1. The Forenoon overcaſt; Afternoon more ſerene, with ſmall Southerly Gales. ☿ $30\frac{1}{20}$.

2. Fair and pleaſant Weather, with ſmall Gales at S W. ☿ $30\frac{2}{20}$.

3. Grey cloudy Weather, blowing freſh in the Forenoon at N E. Afternoon moderate. ☿ $30\frac{4}{20}$.

4. Fair and ſerene Weather, the Horizon ſomewhat cloſe, with eaſy Gales at S. ☿ $30\frac{4}{20}$. In the Afternoon the Gale veer'd to W, and the Sky ſomewhat hazy.

5. Cloſe and cloudy Weather, with ſome drizling Rain in the Forenoon, and ſmall Gales from S to E S E. The Night calm and rainy. ☿ 30.

6. Cloſe foggy Weather, with drizling Rains and calm. ☿ $29\frac{18}{20}$.

7. Fair and pleaſant Weather, ſomewhat cloudy and calm. In the Evening ſmall Gales at E to N E. All Night cloſe foggy Weather. ☿ $29\frac{18}{20}$.

8. Cloſe foggy Weather, with ſmall Northerly Breezes, for the moſt part calm. ☿ $29\frac{16}{20}$.

9. The Forenoon cloſe and cloudy, Afternoon fair and pleaſant, with ſmall Gales at N. In the Evening calm. ☿ $29\frac{14}{20}$.

10. Fair and pleaſant Weather, ſometimes overcaſt, with ſmall Gales from S W to S. ☿ 29 $\frac{18}{20}$.

11. Fair and pleaſant Weather, with ſmall Gales from S to S E. ☿ 30.

12. Fair Weather, ſometimes overcaſt, with moderate Gales at N. ☿ 30 $\frac{2}{20}$.

13. Dry Weather, ſomewhat hazy, with freſh ſharp Weſterly Gales. ☿ 30 $\frac{4}{20}$. In the Evening ſerene and little Wind. ☿ 30 $\frac{2}{20}$.

14. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ 30 $\frac{2}{20}$.

15. Fair and pleaſant Weather, with ſmall Gales from S to S E. In the Evening calm. ☿ 30 $\frac{2}{20}$.

16. The Forenoon fair and pleaſant, with moderate Gales at S E. ☿ 30 $\frac{2}{20}$. In the Afternoon overcaſt, with ſome Rain and ſmall Gales at N W. ☿ 30.

17. The Forenoon fair and pleaſant, with moderate Gales at S E. ☿ 30 $\frac{2}{20}$. The Afternoon overcaſt, and the Gale freſhning at Night. ☿ 30.

18. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Gales at S E. ☿ 30.

19. Cloudy Weather, with a hazy Sky, and ſmall Gales at S E. ☿ 29 $\frac{18}{20}$.

20. Dry cloudy Weather, with fine Gales at S E. ☿ 29 $\frac{17}{20}$.

21. Grey cloudy Weather, with ſome Rain in the Forenoon, and ſmall Breezes at S E, for the moſt part calm; the Afternoon fair. ☿ 29.

22. Cloſe and cloudy Weather, with hazy and calm; in the Afternoon ſome Rain and ſmall Breezes at S E. ☿ 29 $\frac{16}{20}$.

23. Dry Weather, ſomewhaat foggy and cloudy, with ſmall Gales at S E. ☿ 29 $\frac{16}{20}$. In the Evening thick foggy Weather.

24. Grey cloudy Weather, ſomewhat foggy, with moderate Gales at S E. ☿ 29 $\frac{17}{20}$. At Night much Fog.

25. Cloudy and foggy Weather, with fine Gales at S E. ☿ 29 $\frac{15}{20}$. At Night much Rain, Thunder and Lightning, with little Wind. ☿ 29 $\frac{14}{20}$.

26. Cloſe and cloudy Weather, with ſmall Gales at N W. ☿ 29 $\frac{16}{20}$. In the Afternoon ſomewhat hazy, with ſmall drizling Rain.

27. The Weather clearing up with eaſy Gales at S E. ☿ 29 $\frac{14}{20}$. The Afternoon overcaſt; and in the Evening much Rain with ſome Thunder and Lightning, the Wind veering to N W, and back to S E. ☿ 29 $\frac{14}{20}$.

28. Grey cloudy Weather, with ſome Fog, and ſmall Gales from W to N W. ☿ 29 $\frac{17}{20}$.

29. Cloſe and cloudy Weather, with ſmall Gales from N W to N. ☿ 29 $\frac{17}{20}$. At Night ſome Rain.

30. Grey cloudy Weather, ſomewhat cloſe, with freſh Gales at N W. ☿ 29 $\frac{17}{20}$.

May. 1. A fair and ſerene Morning, with ſmall Breezes at W by S. ☿ $29\frac{18}{20}$. All Day and Night fair and pleaſant, with ſmall Breezes at N W. ☿ $29\frac{19}{20}$.

2. Fair and ſerene Weather, with ſmall Breezes at S E, and ſometimes calm. ☿ 30^{d}. In the Afternoon and all Night freſh Gales.

3. The Weather ſomewhat cloudy, with freſh Gales at S E. ☿ $29\frac{17}{20}$. In the Afternoon falling to $29\frac{14}{20}$. The Wind veering to W N W, had much Rain with Thunder and Lightning all Night.

4. The Morning cloſe foggy Weather, almoſt calm. ☿ $29\frac{17}{20}$. The Afternoon clear'd up, blowing freſh from N to N E. ☿ $30\frac{1}{20}$.

5. Fair and pleaſant Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ 30^{d}.

6. Fair and pleaſant Weather, ſomewhat cloudy, with moderate Gales at S E. ☿ $29\frac{19}{20}$. Towards Noon little Wind. In the Afternoon a fine Gale at S E by E, and at Night thick foggy Weather. ☿ $29\frac{12}{20}$.

7. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E. ☿ below $29\frac{18}{20}$.

8. Fair and pleaſant Weather, ſomewhat foggy on the Hills, and ſmall variable Breezes from S W to N W. ☿ $29\frac{18}{20}$. At Night much Fog.

9. Fair and pleaſant Weather, with ſome Fog on the Hills, with ſmall variable Breezes from S W to N W. ☿ 30^{d}. The Afternoon ſerene.

10. The Forenoon fair and pleaſant, ☿ falling from $29\frac{18}{20}$ to $29\frac{7}{20}$. The Afternoon overcaſt with ſmall Gales from S to S E.

11 Grey cloudy Weather, with ſmall Gales N E. ☿ $29\frac{17}{20}$. In the Afternoon ſome Rain.

12. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Northerly Gales. ☿ $29\frac{18}{20}$.

13. Fair and ſerene Weather, with ſmall Gales at S W, ſometimes calm. ☿ above $29\frac{11}{20}$.

14. Fair and ſerene Weather, with ſmall Gales variable from W to N E. ☿ 30^{d}. The Afternoon ſomewhat overcaſt.

15. Fair and pleaſant Weather, with ſmall Gales at N E. ☿ $29\frac{18}{20}$. At Night calm.

16. Fair and ſerene Weather, with ſmall Gales from N E to S E. ☿ falling to $29\frac{17}{20}$. In the Evening overcaſt with ſome Fog.

17. The Morning ſome Fog on the Hills, all Day fair and ſerene, with ſmall Gales at S E. ☿ $29\frac{18}{20}$. At Night calm.

18. The Morning ſomewhat cloſe and foggy, all Day fair and pleaſant with fine Gales at S E. ☿ 30^{d}.

19. Fair and pleaſant Weather, with fine Gales at S E. ☿ 30^{d}.

20. Fair and pleaſant Weather, with freſh Gales at S E, the Sky ſomewhat hazy. ☿ $29\frac{18}{20}$.

21. Grey cloudy Weather, with freſh Gales at S E. ☿ falling below $29\frac{13}{20}$. At Noon ſome ſmall Rain.

22. Cloudy hazy Weather, with ſmall drizling Rains and moderate Gales at S E. ☿ below $29\frac{17}{20}$.

23. Cloſe and cloudy Weather, with moderate Gales at S E. ☿ $29\frac{16}{20}$.

24. Thick hazy Weather, with continual Rain, and freſh Gales from N N E to S E. ☿ falling below $29\frac{13}{20}$.

25. Cloſe and cloudy Weather, with moderate Gales from E to N E. ☿ $29\frac{13}{20}$.

26. The Forenoon thick hazy Weather, and the Afternoon grey cloudy Weather, with ſmall Gales at N E. ☿ riſing above $29\frac{14}{20}$.

27. Grey cloudy Weather, with moderate Gales at S E. ☿ above $29\frac{15}{20}$. Some Rain at Night.

28. Grey cloudy Weather, with the Wind from S to S S E, ſometimes ſmall Gales, and ſometimes blowing freſh. ☿ $29\frac{15}{20}$. Rain at Night.

29. Grey cloudy Weather, with fine Gales at S E, and drizling Rains. ☿ $29\frac{15}{20}$. At Night ſmall Gales at N E, ſometimes calm with thick Weather.

30. Thick foggy Weather, for the moſt Part calm, and ſmall drizling Rains. ☿ $29\frac{13}{20}$. At Night ſmall Gales at S E.

31. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E. ☿ $29\frac{13}{20}$. At Night ſome Rain.

June.

1. Grey cloudy and foggy Weather, with ſome Rain in the Forenoon, and ſmall Gales at W. ☿ $29\frac{13}{20}$. In the Afternoon, riſing to $29\frac{15}{20}$. The Wind veering to N, and the Weather clearing up.

2. The Forenoon fair and pleaſant Weather and calm. ☿ $29\frac{17}{20}$. The Afternoon overcaſt, with ſome ſmall Rain, and ſmall Gales at S E. ☿ falling below $29\frac{16}{20}$. At Night ſome Rain.

3. All this Forenoon cloſe thick rainy Weather, with ſmall Gales at N E. ☿ falling below $29\frac{13}{20}$ The Afternoon dry, cloudy and calm.

4. Fair and pleaſant Weather, with fine freſh Gales from S E to S S E. ☿ above $29\frac{14}{20}$.

5. Fair and ſerene Weather, very hot, with ſmall Gales from W S W to N W. ☿ above $29\frac{15}{20}$.

6. Fair and ſerene Weather, with variable Gales round the Compaſs. ☿ $29\frac{17}{20}$. The Afternoon ſomewhat cloudy, and at Night calm.

7. The Forenoon overcaſt and foggy, with ſmall Gales at S E, and ſince Noon drizling Rains. ☿ falling to $29\frac{14}{20}$. Much Rain in the Night, blowing in Guſts.

8. Cloſe hazy Weather, with drizling Rains all Day, and ſmall variable Breezes, for the moſt Part calm. ☿ $29\frac{13}{20}$. At Night fair.

9. This Morning clearing up, with ſome Drops of Rain and calm. ☿ riſing to $29\frac{16}{20}$. The Afternoon overcaſt, and ſome Rain in the Evening.

10. Grey cloudy Weather, ſomewhat foggy, with ſmall Gales at S E, ſometimes calm. ☿ $29\frac{18}{20}$. The Afternoon and Night drizling Rains.

11. This Morning cloudy and foggy, with drizling Rains and calm. ☿ below $29\frac{18}{20}$. The Afternoon cloſe and foggy, with drizling Rains and ſmall Gales from E S E to S E. ☿ falling to $29\frac{14}{20}$.

12. Cloſe foggy Weather, with little Wind at S E, and ſometimes calm. ☿ $29\frac{13}{20}$. The Afternoon and all Night very much Rain.

13. Cloſe foggy Weather, with much Rain in the Forenoon, and drizling in the Afternoon, with ſmall variable Breezes, ſometimes calm. ☿ $29\frac{13}{20}$.

14. The Morning cloſe and foggy, the Forenoon clear'd up, with fair and pleaſant Weather, and ſmall Breezes at S W. ☿ $29\frac{14}{20}$. The Afternoon overcaſt, with ſmall Gales at S E. In the Evening ſome vehement Thunder, with Lightning and much Rain. ☿ below $29\frac{13}{20}$.

15. The Forenoon cloſe foggy Weather, the Afternoon grey and cloudy, with ſmall Gales from S E to N E, ſometimes calm. ☿ below $29\frac{14}{20}$.

16. The Forenoon cloſe and foggy, with ſome Rain; at Noon cleared up with ſmall Gales from S E. ☿ above $29\frac{13}{20}$. At Night cloudy with ſome Lightning.

17. The Morning very hazy and calm, the Forenoon clear'd up with ſmall Gales at S E. ☿ above $29\frac{14}{20}$. The Afternoon overcaſt, with the Gale veering to N by E, much Rain, Thunder and Lightning. ☿ as before.

18. Grey cloudy Weather in the Morning, and cleared up in the Afternoon, with ſmall Gales at S E. ☿ $29\frac{16}{20}$. The Afternoon overcaſt with freſh Gales continuing all Night. ☿ as before.

19. This Forenoon grey cloudy Weather, ſometimes clearing up, with freſh Gales at S E. ☿ $29\frac{16}{2}$.

20. Fair and cloudy Weather, with moderate Gales at S E. ☿ $29\frac{17}{20}$.

21. The Forenoon fair and ſomewhat cloudy, the Afternoon ſerene and pleaſant, with ſmall Gales at S E. ☿ below $29\frac{16}{20}$.

22. The Forenoon fair and pleaſant, with fine Gales at S E. ☿ below $29\frac{16}{20}$. The Afternoon grey and cloudy, with little Wind.

23. Fair and pleaſant Weather, with ſmall Breezes at S E, for the moſt Part calm, with ſome Lightning in the Night. ☿ $29\frac{18}{20}$.

24. Fair and pleaſant Weather, with ſmall Gales at S E, ſometimes calm. ☿ $29\frac{16}{20}$. At Night overcaſt and calm, with ſome Lightning.

25. Fair and ſerene Weather, with ſmall Gales at S E, in the Forenoon. ☿ $29\frac{16}{20}$. The Afternoon fine freſh Gales from S E to S by E, and blowing very freſh all Night.

26. Fair and pleaſant Weather, blowing very freſh from S by E to S by W, about Noon little Wind. ☿ below $29\frac{16}{20}$. The Afternoon moderate Gales at S E.

27. Fair and ſerene Weather, with moderate Gales at S E. ☿ below $29\frac{16}{20}$.

28. Fair and ſerene Weather, with moderate Gales at S E. ☿ as before.

29. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{14}{20}$. The Evening overcaſt and blowing freſh all Night.

30. Cloudy Weather, and ſomewhat hazy, with freſh Gales from E S E to N E. ☿ below $29\frac{14}{20}$. The Afternoon much Rain and blowing hard all Night at S E. ☿ $29\frac{12}{20}$.

1. Cloudy and hazy Weather, with ſome Rain and hard Gales at S E. ☿ $29\frac{13}{20}$. *July.*

2. The Forenoon fair and ſomewhat cloudy, the Afternoon ſerene, with fine freſh Gales at S E. ☿ below $29\frac{11}{20}$. All Night cloudy.

3. Dry Weather, ſomewhat cloudy, with fine Gales at S E. ☿ $29\frac{14}{20}$.

4. Fair and ſerene Weather, with fine freſh Gales at S E. ☿ $29\frac{14}{20}$. The Evening overcaſt.

5. Fair and pleaſant Weather, ſomewhat cloudy, with a ſmall Shower in the Forenoon, ſome Thunder and eaſy Gales at S E. ☿ above $29\frac{15}{20}$. At Night little Wind.

6. Fair and ſerene Weather, with ſmall Gales at S E. ☿ $29\frac{16}{20}$. At Night little Wind.

7. Fair and pleaſant Weather, ſomewhat cloudy, with fine Gales at S E. ☿ $29\frac{14}{20}$.

8. The Forenoon overcaſt, with ſome Rain and Guſts of Wind at S E; the Afternoon fair and pleaſant, with eaſy Gales at S E. ☿ above $29\frac{11}{20}$. At Night ſome ſmall Rain.

9. Fair and pleaſant Weather, ſometimes cloudy, with fine Gales at S E. ☿ above $29\frac{13}{20}$.

10. The Morning ſomewhat hazy and cloudy, all Day fair and ſerene Weather, with eaſy Gales at S E. ☿ below $29\frac{11}{20}$.

11. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ below $29\frac{12}{20}$. The Afternoon overcaſt and little Wind. ☿ falling to $29\frac{11}{20}$. Some Thunder and Lightning.

12. The Forenoon fair and pleaſant, with ſmall Gales at S E. ☿ below $29\frac{10}{20}$. The Afternoon overcaſt, with ſeveral ſmall Showers of Rain and little Wind, all Night calm.

13. Fair and pleaſant Weather, with ſome Clouds and calm. ☿ $29\frac{12}{20}$. Towards Noon overcaſt, and the Wind in ſmall Gales veering to S W. with cloſe rainy Weather all the Afternoon, in the Evening dry and cloudy, with ſmall Gales at W. ☿ $29\frac{11}{20}$.

14. This Morning and Forenoon cloſe and cloudy Weather, with much Rain and ſmall Gales at W. ☿ $29\frac{14}{20}$. The Afternoon dry and cloudy, the Wind and ☿ as before.

15. Fair and pleaſant Weather, with ſmall Breezes from W to S W, ſometimes calm. ☿ $29\frac{16}{20}$.

16. Dry cloudy Weather, with ſmall Gales at S E. ☿ $29\frac{14}{20}$.

17. Fair and pleaſant Weather, ſometimes cloudy, with fine freſh Gales at S E by S. ☿ above $29\frac{14}{20}$.

18. Fair and pleaſant Weather, ſometimes overcaſt, with freſh Gales at S E. At Night blowing very hard. ☿ $29\frac{14}{20}$.

19. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ $29\frac{16}{20}$.

20. Fair and ſerene Weather, with fine freſh Gales in the Forenoon, and fine freſh Gales in the Afternoon. ☿ $29\frac{15}{20}$. At Night calm.

21. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{15}{20}$.

22. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{15}{20}$. At Night ſometimes little Wind, at other Times blowing freſh.

24. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{16}{20}$. Afternoon blowing freſh.

25. Very fair and ſerene Weather, with ſmall Gales at S E. ☿ $29\frac{17}{20}$. At Night ſome Lightning.

26. Grey cloudy Weather, with ſmall Gales at S E, at Night calm and ſome Lightning.

27. Grey cloudy Weather, with ſmall Gales at N N W in the Forenoon, veering to N E in the Afternoon. ☿ $29\frac{16}{20}$. At Evening much overcaſt, with Thunder, Lightning and ſome Rain.

28. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall variable Gales from N W to N E. ☿ $29\frac{15}{20}$.

29. Grey cloudy Weather, with ſmall variable Gales from N E to S W, ſometimes calm. ☿ $29\frac{15}{20}$. In the Evening a ſmall Shower of Rain, with ſome Thunder and Lightning.

30. Fair and ſerene Weather and calm. ☿ $29\frac{14}{20}$. In the Afternoon ſmall Gales at N N W, very hot and ſultry; at Night little Wind with ſome Thunder and Lightning.

31. Fair and pleaſant Weather, ſometimes cloudy, with fine Gales at S E. ☿ $29\frac{16}{20}$. Some Thunder and Lightning in the Afternoon.

Auguſt. 1. The Morning ſomewhat overcaſt, all Day fair and pleaſant, with ſmall Gales at S E. ☿ $29\frac{16}{20}$. The Afternoon fine Gales.

2. Very fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{16}{20}$.

3. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{18}{20}$.

4. Fair and ſerene Weather, with fine Gales at S E. ☿ $29\frac{18}{20}$.

5. The Forenoon grey cloudy Weather and calm, the Afternoon ſerene with ſmall Gales at S E by E. ☿ $29\frac{14}{20}$.

6. Fair and ſerene Weather, with ſmall Gales at N N W. ☿ $29\frac{16}{20}$. The Evening overcaſt, with ſome Lightning.

7. Fair Weather, ſometimes overcaſt, with freſh Gales from S to S S E. ☿ $29\frac{17}{20}$.

8. Fair and pleaſant Weather in the Forenoon, and cloudy in the Afternoon, with ſmall Gales at S S E. ☿ $29\frac{16}{20}$.

9. Fair and ſerene Weather, with ſmall Gales in the Forenoon, and freſhning in the Afternoon at S E. ☿ $29\frac{12}{20}$.

10. Fair and ſerene Weather, with ſmall Gales from S E to E by S. ☿ $29\frac{16}{20}$. At Night calm.

11. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Gales in the Afternoon, and Lightning at Night. ☿ $29\frac{12}{20}$.

12. Fair and ſerene Weather, with ſmall Gales at S S E, at Night calm and hazy. ☿ $29\frac{17}{20}$.

13. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Breezes in the Afternoon. ☿ $29\frac{18}{20}$

14. Fair Weather, ſometimes overcaſt, with ſmall Gales at N W by W. ☿ $29\frac{15}{20}$.

15. Fair Weather, ſomewhat cloſe, and ſome Rain in the Afternoon, with ſmall variable Gales. ☿ $29\frac{15}{20}$.

16. Fair and ſerene Weather, calm in the Forenoon, and ſmall variable Breezes in the Afternoon. ☿ $29\frac{15}{20}$.

17. The Weather cloudy and overcaſt, with ſome Rain in the Afternoon, and ſmall variable Gales round the Compaſs. ☿ $29\frac{16}{20}$.

18. Grey cloudy Weather, with ſome Rain, and eaſy Gales at N E. ☿ $29\frac{16}{20}$. In the Night very freſh Gales from N E to S E, and ſometimes at N W.

19. Grey cloudy Weather, with ſome Rain, and freſh Gales from S E to E S E. ☿ $29\frac{15}{20}$.

20. Fair and pleaſant Weather, with fine Gales at S E. ☿ $29\frac{16}{20}$.

21. Fair and pleaſant Weather, with fine Gales at S E. ☿ $29\frac{16}{20}$.

22. Fair and ſerene Weather, with ſmall Gales at S E. ☿ $29\frac{18}{20}$.

23. Fair and pleaſant Weather, with ſmall Gales at S E. In the Afternoon ſomewhat cloudy, and the Gale freſhning. ☿ $29\frac{18}{20}$. In the Night blew very freſh.

24. Fair and ſerene Weather, with moderate Gales at S E. In the Evening much overcaſt, and at Night much Rain with ſome Thunder and Lightning. The Wind at N W. ☿ $29\frac{15}{20}$.

25. The Morning grey and cloudy, all Day fair and pleaſant, with ſmall Gales at N W. In the Afternoon veering to S E, and at Night calm. ☿ $29\frac{16}{20}$.

26. Fair and pleaſant Weather, with ſmall Gales at S E. ☿ $29\frac{16}{20}$.

27. Grey cloudy Weather, with drizling Rains this Morning and Forenoon; and fair in the Afternoon, with ſmall variable Gales. ☿ $29\frac{15}{20}$.

28. Fair and pleaſant Weather, with ſmall Gales from N to N E. ☿ $29\frac{17}{20}$. At Night calm.

29. Fair pleaſant Weather, with ſmall Gales at N E. ☿ $29\frac{17}{20}$. At Night ſome drizling Rain.

30. Fair and pleaſant Weather, ſomewhat cloudy, with eaſy Gales at N E. ☿ 29 $\frac{16}{20}$.

31. Grey cloudy Weather, with ſome Rain, and moderate Gales at N E. In the Night blowing in Guſts. ☿ 29 $\frac{15}{20}$.

September. 1. Fair Weather, ſometimes overcaſt, with freſh Gales from N to N N W. ☿ 29 $\frac{14}{20}$.

2. Cloudy Weather, with ſome Rain, and bluſtering Gales at N N W. ☿ 29 $\frac{15}{20}$.

3. Fair and pleaſant Weather, with moderate Gales at N N W, ſometimes overcaſt and blowing freſh; at Night little Wind. ☿ 29 $\frac{16}{20}$.

4. Fair and pleaſant Weather, with ſmall Gales from N W to N. At Night calm. ☿ 29 $\frac{18}{20}$.

5. Fair and pleaſant Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

6. Fair and pleaſant Weather, with ſmall Gales at N and N by W. ☿ 29 $\frac{18}{20}$.

7. Fair and pleaſant Weather, with ſmall Gales at N by W and N N W. ☿ below 29 $\frac{18}{20}$.

8. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ below 29 $\frac{18}{20}$.

9. Fair and ſerene Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

10. Fair and ſerene Weather, with ſmall Gales at N. ☿ 29 $\frac{18}{20}$.

11. Fair and ſerene Weather, with ſmall Gales at S E, and at Night veering to E N E. ☿ 29 $\frac{18}{20}$.

12. Fair and ſerene Weather, with ſmall Gales at S S E. ☿ 29 $\frac{18}{20}$.

13. The Forenoon fair and pleaſant, the Afternoon grey cloudy Weather, with ſmall Gales at E S E. ☿ 30^d.

14. Grey cloudy Weather, with ſmall Gales from E S E to E N E, ſometimes calm. ☿ 30^d. In the Night variable Gales with ſome Rain.

15. Grey cloudy Weather, with ſmall Gales from N E to S E by E. ☿ 30^d.

16. The Morning cloudy and overcaſt, all Day clear'd up with eaſy gentle Gales at S E. ☿ 30^d.

17. Fair and ſerene Weather, with moderate Gales at S E. ☿ 30^d.

18. Fair and ſerene Weather, with moderate Gales at S E. ☿ 30^d.

19. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 29 $\frac{19}{20}$.

20. Cloſe hazy Weather, with ſmall Gales from N E. ☿ 30 $\frac{1}{20}$. In the Afternoon ſome Rain.

21. Grey cloudy Weather, with moderate Gales at N by E and N N E. ☿ 30 $\frac{3}{20}$. In the Evening little Wind.

22. Dry temperate Weather, ſomewhat grey and cloudy, with ſmall Gales at N by W. ☿ 30 $\frac{5}{20}$.

23. Fair and pleaſant Weather, ſomewhat cloudy, with ſmall Gales at N N W. ☿ 30 $\frac{4}{20}$.

24. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ $30\frac{2}{20}$.

25. Fair and pleaſant Weather, with ſmall Gales at N N W. ☿ $30\frac{1}{20}$.

26. Fair Weather, ſomewhat cloudy, in the Afternoon ſome Showers of Rain, and ſmall Gales from N N W to N W by W. ☿ $30\frac{2}{20}$, riſing at Night to $30\frac{4}{20}$.

27. Fair and cloudy Weather, with ſmall Gales from N N W to N. ☿ $30\frac{4}{20}$.

28. Fair and pleaſant Weather, with ſmall Gales from N by W to N by E.

29. Dry and cloudy Weather, with ſmall Gales at N N W.

30. Fair and pleaſant Weather in the Forenoon, with ſmall Gales at N N E, the Afternoon overcaſt with Guſts of Wind and ſome Showers of Rain.

1. The Morning overcaſt, all Day fair and pleaſant, with ſmall Gales from N N E to N. *October.*

2. The Morning grey and cloudy, all Day fair and pleaſant, with ſmall Gales at N by W.

3. Grey cloudy Weather, with moderate Gales at N and N by E, ſometimes blowing freſh; at Night thick and hazy with ſome Rain.

4. Thick hazy Weather, towards Noon clear'd up, Afternoon overcaſt with Rain and dark Weather. Small Gales at N N E.

5. Grey cloudy Weather, with ſmall Gales at N N E, inclining to Rain.

6. Thick hazy Weather, with much Rain and ſmall Gales at N N E. ☿ below 30^{d}.

7. The Morning cloſe and cloudy Weather, with ſome Rain, and ſmall Gales at N and N by W. ☿ below 30^{d}. All Day thick hazy Weather, with drizling Rains.

8. Hazy Weather, with drizling Rains and ſmall Gales at N N E and N E. ☿ $30\frac{3}{20}$.

9. Cloſe hazy Weather, with drizling Rains, and ſmall Gales at N E. ☿ $30\frac{4}{20}$. ☿ at Night $30\frac{5}{20}$.

10. Cloſe and cloudy Weather, with ſome Rain, and moderate Gales at N E. ☿ $30\frac{5}{20}$.

11. Grey cloudy Weather, with ſome Rain at Night and ſmall Gales at N N E. ☿ $30\frac{6}{20}$.

12. The Morning ſerene, with ſmall Gales at N E. ☿ $30\frac{7}{20}$. The Afternoon grey cloudy Weather. ☿ $30\frac{6}{20}$.

13. Dry cloudy Weather, with ſmall Gales at N by E. ☿ $30\frac{6}{20}$. The Afternoon more ſerene and almoſt calm.

14. Grey cloudy Weather, with moderate Gales at N E, ſometimes blowing freſh. ☿ $30\frac{2}{20}$.

15. Grey cloudy Weather inclining to Rain, with moderate Gales at N by W. ☿ 30 $\frac{3}{20}$. At Night much Rain.

16. Grey cloudy Weather, with ſome Rain at Night, and freſh Gales at N and N by W. ☿ 30 $\frac{4}{20}$.

17. Grey cloudy Weather, with moderate Gales at N by E, blowing freſh in the Night at N N W. ☿ 30 $\frac{4}{20}$.

18. Fair and pleaſant Weather, with moderate Gales at N W by N. ☿ 30 $\frac{5}{20}$.

19. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

20. Fair and ſerene Weather, with ſmall Gales at W N W and W by N. ☿ 30 $\frac{6}{20}$.

21. Fair and ſerene Weather, with ſmall Gales at N E and N E by E. ☿ 30 $\frac{6}{20}$.

22. Fair and ſerene Weather, with ſmall Gales at N and N by E. ☿ 30 $\frac{6}{20}$.

23. Fair and ſerene Weather, with ſmall Northerly Breezes, ſometimes calm. ☿ 30 $\frac{1}{20}$.

24. A grey cloudy Morning, blowing freſh at N N W. All Day fair and pleaſant, with moderate Gales at N. ☿ 30 $\frac{5}{20}$.

25. The Forenoon overcaſt, with fine freſh Gales at W N W, and ſharp Weather, the Afternoon more ſerene and ſmaller Gales. ☿ 30 $\frac{7}{20}$.

26. Fair ſerene Weather, with fine ſharp Gales at N N W. ☿ 30 $\frac{8}{20}$.

27. Fair and ſerene Weather, with ſmall Gales at E S E and S E, ſometimes calm. ☿ 30 $\frac{6}{20}$.

28. Grey cloudy Weather, with freſh Gales at N N W and N. ☿ 30 $\frac{8}{20}$.

29. Fair Weather, ſomewhat cloudy, with moderate Gales from N by W to N W. ☿ 30 $\frac{8}{20}$

30. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{8}{20}$.

31. Fair and ſerene Weather, with moderate Gales at N by W and N. ☿ 30 $\frac{10}{20}$. Very cold.

November. 1. Fair and ſerene Weather, with ſmall Gales at W N W. ☿ 30 $\frac{6}{20}$.

2. Grey cloudy Weather, with ſome Rain in the Evening, and moderate Gales at N N W. ☿ 30 $\frac{5}{20}$.

3. Fair and ſerene Weather, ſomewhat hazy, with very freſh Gales at N by W and N N W. ☿ below 30 $\frac{6}{20}$.

4. Fair and ſerene Weather, with ſmall Breezes at N by E. ☿ 30 $\frac{6}{20}$. At Night calm.

5. Fair and ſerene Weather, with ſmall Breezes at S E. Sometimes calm. ☿ 30 $\frac{6}{20}$.

6. Fair and ſerene Weather, with ſmall Breezes from W S W to W N W. ☿ 30 $\frac{5}{20}$.

7. Fair and ſerene Weather, with ſmall Gales at N W. ☿ $30\frac{6}{20}$.

8. This Morning foggy; all Day ſerene, with moderate Gales from S W to N W. ☿ $30\frac{6}{20}$.

9. Fair and pleaſant Weather, ſometimes overcaſt, with moderate Gales at S E and E S E. ☿ $30\frac{4}{20}$. At Night little Wind and calm.

10. Fair and ſerene Weather, with moderate Gales at S E. ☿ $30\frac{5}{20}$.

11. Grey cloudy Weather, with ſmall Gales at N and N by W. In the Evening calm. ☿ $30\frac{2}{20}$.

12. Fair and pleaſant Weather, with ſmall Gales at N. In the Evening calm. ☿ $30\frac{4}{20}$.

13. Fair and pleaſant Weather, with ſmall Gales from S by E to S E. ☿ $30\frac{4}{20}$. At Night calm.

14. Grey and cloudy Weather, ſomewhat hazy, with moderate Gales from W N W to N W. ☿ $30\frac{5}{20}$.

15. Grey cloudy Weather, with freſh Gales at N N E, and ſome ſmall Rain. ☿ $30\frac{5}{20}$.

16. Fair and pleaſant Weather, with moderate Gales from S to S E. ☿ $30\frac{6}{20}$.

17. Grey cloudy Weather, with moderate Gales from S by W to E S E. ☿ $30\frac{5}{20}$. At Night blowing hard, and veering to N W, with much Rain.

18. Grey cloudy Weather, with freſh Gales at N W. In the Afternoon blowing very hard. ☿ 30^{4}.

19. Grey cloudy Weather, with moderate Gales at N W. ☿ $30\frac{6}{20}$. At Night riſing to $30\frac{10}{20}$.

20. Fair and pleaſant Weather, with ſmall Gales from N to E, and about to S E. In the Evening little Wind. ☿ $30\frac{10}{20}$, falling to $30\frac{6}{20}$.

21. Grey cloudy Weather, for the moſt Part calm, with ſmall Northerly Breezes. ☿ $30\frac{6}{20}$.

22. Grey cloudy Weather, with moderate Gales at N W. ☿ $30\frac{6}{2}$.

23. Grey cloudy Weather, with fine Gales at N W. ☿ 30^{6}.

24. Grey cloudy Weather, with eaſy Gales from W N W to N W. ☿ $30\frac{6}{20}$.

25. Grey and cloudy Weather, with eaſy Gales at N W. ☿ $30\frac{6}{20}$.

26. Fair and ſerene Weather, with ſmall Gales at N W, ſometimes calm. ☿ $30\frac{6}{20}$.

27. Thick hazy Weather, with drizling Rains, and at Night much Rain, with ſmall Southerly Breezes, for the moſt Part calm. ☿ $30\frac{2}{20}$.

28. Hazy Weather, with drizling Rains all Day and Night, and ſmall Gales from N to N N E. ☿ $30\frac{1}{20}$, riſing to $30\frac{6}{20}$.

29. Grey cloudy Weather, with ſmall Gales at N N E. ☿ 30 $\frac{5}{20}$.

30. Grey cloudy Weather, with fine Gales at N. ☿ 30 $\frac{8}{20}$.

December, 1701. 1. Grey cloudy Weather, and very cold with fine Gales at N. ☿ 30 $\frac{12}{20}$. Some Froſt at Night.

2. Dry Weather, ſomewhat cloudy, with moderate Gales at N N W. ☿ 30 $\frac{8}{20}$.

3. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

4. Fair and ſerene Weather, with ſmall Gales at N W and W N W. ☿ 30 $\frac{6}{20}$. At Night overcaſt.

5. Dry cloudy Weather, with moderate Gales at N by W. ☿ 30 $\frac{9}{20}$.

6. Fair and pleaſant Weather, with fine Gales from E to S E, and at Night calm. ☿ 30 $\frac{7}{20}$, falling to 30 $\frac{5}{20}$.

7. Grey cloudy Weather, with freſh Gales at N W and W N W. ☿ 30 $\frac{8}{20}$.

8. Fair Weather, ſomewhat cloudy, with freſh Gales at N W. ☿ 30 $\frac{12}{20}$.

9. Fair and pleaſant Weather, with fine Gales at N N W. ☿ 30 $\frac{11}{20}$.

10. Fair and ſerene Weather, with ſmall Gales at N W to N. ☿ 30 $\frac{11}{20}$. At Night calm.

11. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{1}{20}$.

12. Fair and ſerene Weather, ſometimes cloudy, with ſmall Gales at N W. ☿ 30 $\frac{9}{20}$.

13. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{7}{20}$. At Night calm.

14. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$. At Night calm.

15. Fair and ſerene Weather, with ſmall Gales at S S W. ☿ 30 ^{8}. At Night the Gale freſhned from S S E.

16. Grey cloudy Weather, with moderate Gales at S E. ☿ 30 $\frac{6}{20}$. At Night ſome Rain.

17 Grey cloudy Weather, with drizling Rains, and ſmall Gales at N W. ☿ 30 $\frac{5}{20}$. At Night calm.

18. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{6}{20}$. Some Sleet in the Night.

19. Grey cloudy Weather, with moderate Gales at N W. ☿ 30 $\frac{5}{20}$.

20. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{5}{20}$. At Night 30 $\frac{4}{20}$.

21. The Forenoon ſomewhat hazy and calm. ☿ 30 $\frac{5}{20}$. The Afternoon ſerene, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

22. Fair and ſerene Weather, freezing, with freſh Gales at N N W. ☿ 30 $\frac{11}{20}$.

23. Serene Weather, freezing hard, with freſh Gales at N N W. ☿ 30 $\frac{14}{20}$. At Night little Wind.

24. Serene Weather, freezing hard, with moderate Gales at W N W. ☿ 30 $\frac{11}{20}$.

25. Fair froſty Weather, with moderate Gales at N W. ☿ 30 $\frac{10}{20}$.

26. Fair froſty Weather, with ſmall Gales from W N W to N N W. ☿ 30 $\frac{10}{20}$. At Night Fog.

27. Fair and ſerene Weather, freezing with little Wind at N W, for the moſt part calm. ☿ 30 $\frac{9}{20}$.

28. Fair and ſerene Weather, freezing with ſmall Breezes at N, and ſometimes calm. ☿ 30 $\frac{8}{20}$.

29. Fair and ſerene Weather, freezing with ſmall Northerly Breezes, for the moſt part calm. ☿ 30 $\frac{6}{20}$. At Night ſome Wind and Rain.

30. The Morning foggy, all Day fair and pleaſant, with ſmall Gales from S E to E by S. ☿ 30 $\frac{4}{20}$.

31. Cloſe and cloudy Weather, with drizling Rains, for the moſt part calm. ☿ 30 $\frac{2}{20}$.

January, 1702.

1. Thick hazy Weather, with drizling Rains, for the moſt part calm, with ſmall variable Breezes. ☿ 30 $\frac{2}{20}$.

2. Grey cloudy Weather, with ſome Rain, and ſmall Gales at N E. ☿ 30 $\frac{4}{20}$.

3. Grey cloudy Weather, with ſmall Gales at N and N N W. ☿ 30 $\frac{8}{20}$.

4. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{9}{20}$.

5. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{6}{20}$. Afternoon and Night ſerene.

6. Fair and pleaſant Weather, with moderate Gales at S E. In the Evening and all Night calm. ☿ 30 $\frac{2}{20}$.

7. Cloſe and hazy Weather, with ſmall Gales at E S E and S E, ſometimes calm. ☿ 30 $\frac{2}{20}$.

8. Cloſe and cloudy, in the Morning little Wind, towards Noon blowing ſomewhat freſh at N N W, and in the Evening moderate. ☿ 30 $\frac{2}{20}$, riſing to 30 $\frac{6}{20}$.

9. Grey cloudy Weather, with ſmall Northerly Gales. ☿ 30 $\frac{4}{20}$.

10. Grey cloudy Weather, with ſmall variable Gales, ſometimes calm. ☿ 30 $\frac{4}{20}$.

11. Fair and ſerene Weather, with ſmall Breezes at S E. ☿ 30 $\frac{5}{20}$.

12. The Weather overcaſt, with moderate Gales at W N W. ☿ 30 $\frac{6}{20}$.

13. Fair and pleaſant Weather, with moderate Gales at N W. ☿ 30 $\frac{10}{20}$.

14. Fair and ſerene Weather, with ſmall Gales at N. ☿ 30 $\frac{10}{20}$.

15. Fair and ſerene Weather, with ſmall Gales at S E. ☿ 30 $\frac{8}{20}$.

16. Grey cloudy Weather, with ſmall Gales from S S W to S E. The Afternoon cloſe and hazy, with ſome Rain. ☿ 30 $\frac{2}{20}$.

17. Cloſe hazy Weather, with moderate Gales from N W to N by W. ☿ 30 $\frac{2}{20}$. At Night little Wind. *The* Chineſe *New-Year began this Day*.

18. Cloſe and cloudy Weather and calm. ☿ 30 $\frac{2}{20}$. The Afternoon ſmall drizling Rains.

19. Grey cloudy Weather, with freſh Gales at N by W, and a little Snow. ☿ 30 $\frac{6}{20}$.

20. Grey cloudy Weather, with ſmall Gales at N W, the Afternoon ſerene, and freezing hard at Night. ☿ 30 $\frac{6}{20}$.

21. Fair and ſerene Weather, freezing, with ſmall Gales at N N W, for the moſt part calm. ☿ above 30 $\frac{6}{20}$.

22. Fair ſerene Weather, freezing hard, with ſmall Northerly Breezes, for the moſt part calm. ☿ 30 $\frac{8}{20}$.

23. Grey cloudy Weather and calm. ☿ 30 $\frac{6}{20}$.

24. Cloſe hazy Weather, with drizling Rains and calm. ☿ 30 $\frac{7}{20}$.

25. Grey cloudy Weather, with ſmall Gales at N E. ☿ 30 $\frac{6}{20}$. At Night little Wind and ſome Rain.

26. Cloſe and cloudy Weather, with ſmall Gales at N E. ☿ 30 $\frac{8}{20}$. At Night calm. 30 $\frac{2}{20}$.

27. Thick hazy Weather, with drizling Rains and ſmall Gales at N by E. ☿ 30 $\frac{1}{20}$, blowing freſh at Night.

28. Grey cloudy Weather, with freſh Gales at N N W. ☿ 30 $\frac{6}{20}$. At Night 30 $\frac{8}{20}$.

29. Grey cloudy Weather, with fine Gales at N W. ☿ 30 $\frac{8}{20}$.

30. Fair and pleaſant Weather, with moderate Gales at N W. ☿ 30 $\frac{7}{20}$.

31. Fair and ſerene Weather, with ſmall Gales at N W. ☿ 30 $\frac{6}{20}$.

A Regiſter of the Weather *for* 1692. *by Mr.* J. Locke. n. 298. p. 1917.

IX. I herewith ſend you a Copy of my Regiſter of the Weather at *Oates* in *Eſſex*, from the *9th* of *December* 1691, to the End of the Year 1692. I ſhall firſt explain ſome Things in the Table.

The *Firſt* Column having D at the Top, contains the *Day* of the Month.

The next with H, the *Hour* of the Day, which beginning from 1 of the Clock in the Morning, I count round in one continued Series to 24, which is 12 of the Clock at Night.

The Column *Ther* is that of the Thermoſcope, which was a ſealed one, whereof you will find a larger Account hereafter.

The Column *Bar* marks the height of the *Mercury* in the Baroſcope.

The firſt Number is the Inches of its height, the ſecond Number marks the 20th Parts of an Inch above that Inch mark'd by the firſt Number.

The Column *Hyg* is that which marks the Moiſture of the Air. The Inſtrument I us'd was the Beard of a wild Oat, of which each Turn was divided into ſixteen Degrees.

The Column of the Wind mark'd the Point the Wind was in, but not always exactly, becauſe the Weathercock viſible out of my Window, was ſtiff, and turn'd not eaſily; nor was the Houſe it ſtood on ſituate exactly Eaſt and Weſt; ſo that it was not eaſy by the ſtanding of the Weathercock, to know exactly the Point of the Wind: Wherefore I contented myſelf to ſet down barely one of the 4 Cardinal Points, when the Wind was pretty near it; and when it was more remote, the two Cardinal Points between which it was, putting the Letter of the Cardinal Point firſt to which it was neareſt; as when the Wind was between the South and the Weſt, if it were nearer the Weſt than the South, I writ W. S. and ſo of the reſt.

I mark'd beſides, the Force of the Wind, which I divided into four Degrees. 1. When it juſt moved the Leaves. 2. When it blew a pretty freſh Gale. 3. When it was hard and whiſtling Wind. 4. When it blew a Storm. Though theſe Diviſions were not made with that Exactneſs as they might have been, had one had an Inſtrument on purpoſe, yet they may give ſome Help to thoſe who would make Obſervations from ſuch Regiſters as theſe, (0) was when there was not Wind enough to move a Leaf as I could ſee.

As to the Weather, *Cloudy* ſignifies more of the Sky (viſible out of the Windows of my Study, which were Eaſt and South) cover'd with Clouds, than not. *Fair* the contrary. *Between* when it was uncertain whether more of the Sky was covered or clear. *Cover'd* when no part of the clear Sky appear'd. *Cloſe* when the Sky was cover'd with one uniform thick Cloud.

I have often thought that if ſuch a Regiſter as this were kept in every County in *England*, and ſo conſtantly publiſhed, many Things relating to the Air, Winds, Health, Fruitfulneſs, *&c.* might be collected from them, and ſeveral Rules and Obſervations concerning the Extent of Winds and Rains, *&c.* be in Time eſtabliſh'd, to the great Advantage of Mankind. From this ſolitary one there is little to be collected, beſides the ordinary Obſervation, which I ſet down commonly every Morning, there ſeldom happen'd any Rain, Snow, or other remarkable Change, which I did not ſet down.

N. B. That the Thermoſcope mark'd 4, which I made uſe of till *Mar.* 7, 1701. was one of thoſe ſold by Mr. *Tompion*, wherein 0 mark'd Temperate, and the Figures from thence increaſing both upwards and downwards, ſhew'd the Increaſe of Heat and Cold from Temperate. *Sept.* 22. 1701. I began to uſe a new ſealed Thermoſcope, adjuſted to a Scale made by Mr. *John Patrick*, who places 0 at the Top, ſuppoſing it to be the Heat under the Line, and ſo the Figures increaſe downwards, with the Increaſe of Cold. Temperate being placed at 45. This Thermoſcope is mark'd 5 in my Regiſter.

December, 1691.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
9	16	1. 2	30. $\frac{4}{20}$		S 1	Fog.
10	17	2. 1	4		S E 1	Fair.
11	10	3. 1	4		S E 1	Fog.
12	9	3. 6	3		E 1	Froſt, Cloſe.
13	9	3. 4	30. 0		E 1	Cloſe.
14	9	3. 7	29.17		E 2	Froſt, Fair.
15	9	4. 2	30. 0		E 3	Froſt, Fair.
16	9	4. 4	4		E 3	Froſt, Fair.
17	9	4. 6	6		E 1	Froſt, Fair.
18	9	4.	5		N E 1	Cloſe.
19	9	3. 3	3		N E 1	Fog, Thaw.
	24		29.19		1	Cloudy, a little Rain next Morning.
20	10	3. 4	18		N 1	Cloſe.
21	9	3. 6	19		N 1	Fog, Froſt.
22	9	4.	18		N 1	Cloſe.
24	10	2. 6	14		S W 2	Cloudy.
25	21	2. 1	15			Fair.
26	21	1. 7	13		W 3	Cloſe.
	24		12			Rain before next Morning.
27	18	1. 6	6			
28	1	2. 6	9		S W 2	Fair.
	22		8			Rain.
	24		7		S 2	Rain hard.
29	9	3.	4			Cloſe, and ſome Time after Rain.
	19	2. 7	4			Snow beginning at 6.
30	8	3. 7	10		N W	Fair.
31	9	4. 7	12		N W 0	Fair, hard Froſt.
	17	3. 3	10		S E 1	Cloudy, Thaw.

January 1692.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
1	9	3· 7	9· 11	47	S E 1	Cloſe, Snow at 10.
2	9	3· 7	14	43	W 1	Fair.
3	9	3· 5	8	41	S 2	Clouds.
4	8	3· 6	11	43	S 1	Cloudy.
5	9	3· 7	13	43	S 1	Cloudy.
6	8	4· 3	11	36	S 2	Cloſe.
	16	4·	8	36	E 3	Cloſe.
	20	4· 2	6	41		Snow.
7	10	4· 1	7	45	E 2	Cloſe.
	4	3· 7	17			Cloſe.
8	9	4· 1	30·	45	N E 1	Cloſe.
9	9	2· 6	29· 18	50	S 3	Cloſe.
	20		15			Rain.
10	9	2· 7	18	44	S W 1	Fair.
	12			26		In the Shade.
11	9	2· 6	30· 4	48	W N 1	Cloſe, with a little Fog.
	24	2· 5	30· 8	41		Very fair all the Afternoon, now cloſe.
12	9	2· 7	9	44	N 1	Miſty.
13	9	3· 4	9	46	S 1	Cloſe.
14	9	3· 7	7	48	E 1	Fog.
15	9	4· 4	6	31	E 1	Fog, Froſt.
16	9	4· 5	2	45	N 1	Fair, hard Froſt.
17	10	4· 1	29· 18	43	N E 2	Cloſe, hard Froſt.
18	8	4· 1	12	35	N W 2	Fair, Rain & Snow for an Hour about 16.
19	9	3· 7	9	44	N W 2	Snow till 13.
20	8	4· 5	5	43	N W 2	Fair. Some Clouds. Snow in the After-
21	9	5· 7	6		N 2	Fair. Snow in the Afternoon.
22	9	5· 6	9	18	N W 2	Very fair, hard Froſt.
	10	6· 2	11			In a Northern Cloſet without Fire at any Time.
	24	6· 5½				In the ſame Cloſet, very hard Froſt.
23	9	5· 7	11	31	N W 2	Fair, Snow a little at 14.
24	9		11	28	N W 1	Cloudy, hard Froſt.
25	9	5· 6	10	31	N W 1	Fair, hard Froſt.
26	9	6· 0	9	32	N W 1	Cloudy, hard Froſt.
27	7	5· 3	7	33	N 1	Cloudy, hard Froſt.
28	9	4· 6	4	33	N 1	Snow in the Night, and Snow ſtill.
29	9	5· 6	2	32	W 1	Cloſe, Snow all Afternoon.

N. B. I ſuſpect that from the 23d to the 29th incluſively, the Hygroſcope has been counted 16 Degrees, *i. e.* one whole Turn too high, it being all that while very hard Froſt.

	D.	H	Ther. 4	Bar.	Hyg.	Wind:	Weather.
	30	9	4. 4	2		N W 2	Snow.
	31	9	5. 3	8		N W 1	Cloſe.
February.	1	8	5. 0	10	19	W	Fog.
	2	9	5. 6	11	19	W 1	Fog.
	3	8	5. 7	11	20	W 1	Fog.
	4	9	5. 5	9		E 2	Cloſe.
	5	9	5. 4	7	26	E 3	Cloſe, Snow in the Evening.
	6	9	5. 1	29. 0	20	E 1	Snow.
	7	9	4. 6	2		N 1	Cloſe Fog, little Thaw at 12.
	8	9	4. 6	29. 0	40	N E 2	Fog, Snow in the Night.
	9	8	5. 3	29. 0		N E 2	Snow.
	10	9	5. 5	1		N E 2	Cloſe.
	11	8	6.	8		W 1	Fair.
	12	9	7. 0	11		N W	Cloſe, freezing exceſſively.
	13	9	4. 2	5		S W 1	Cloſe Thaw. It may be obſerv'd between the Thermoſcope to-day and yeſterday Morning, there is the Difference of two whole Degrees and $\frac{6}{8}$ a greater Riſe than one ſhall ordinarily find. The Thermoſcope was unmov'd in a Corner of a very large Room, out of all Reach of the Fire, whereby it might be alter'd.
	14			7			Cloſe.
	16	12		10			Cloſe.
	17	19		9			Fog.
	18	12		5		W	Snow.
	26	2		11		W 2	Cloſe.
	27	9	2. 3	29. 8		W 2	Fair, Rain from 15 to 19.
	28	9	3. 1	6		W 1	Cloſe, Snow laſt Night.
	29	9	3. 6	6		S W 2	Cloudy, Snow laſt Night.
March.	1	8	2. 7	28. 17		S W 3	Fair.
	2	8	3. 1	29. 5		S W 3	Fair.
	3	7	2. 6	8		W S 2	Fair.
		16	1. 4	8		W S 1	Rain very gently till 20, hard till 23.
	4	9	3. 1	14		N E 2	The Ground cover'd with Snow. Cloſe.

D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.
5	9	3. 4	18		W 2	Cloudy.
6	9	2. 4	11		W 2	Rain till 16.
	16	2. 0	9		W 1	Rain.
	22	2. 2	10			Fair.
7	9	3. 5	10		W 2	A little dropping.
	12		9		W N 2	Snow for ¼ Hour.
8	9	3. 3	14		W 1	Fair.
9	8	3. 3	15	25	S W 2	Fair.
10	9	6	19	17	S 1	Fair.
	17	2. 2	18	19	W 2	A little Rain.
11	9	1	19	25	W N 1	Cloſe.
12	9	5	30. 1	23	N W 1	Cloſe.
	14	2. 0	30. 0	24	W N 2	Cloſe. Small Rain at 15 till 16.
	16	1. 7	29.19	40	W N 1	Very gentle Rain.
	23	7	16		N W 2	Hard Rain for 3 or 4 Hours paſt.
13	9	2. 3	13		W N	Very gentle ſmall Rain.
	12		11		N W 2	Fair.
14	9	2. 6	11	27	N W 2	Cloſe.
	16	5	13	25	N E 3	Fair.
15	8	4. 0	16	26	N E 2	Cloſe, Froſt laſt Night.
16	9	3. 4	14	25	N W 1	Cloſe.
	13	0	13	20	N W 1	Fair. Rain in the Night.
17	9	3. 0	8	25	N E 1	Cloſe.
	13		7		S E 1	Cloudy.
	18	2. 2	6		S E 2	Cloſe.
	19		5	29		Small Rain.
	23		4	35		Cloſe. Much Rain in the Night.
18	8	2. 3	1	41	W S 2	Cloſe.
19	9	6	3	34	S W 2	Cloudy. (dropping.
20	9	2	2	31	S 2	Cloudy. Rain laſt Night, Houſes yet
21	8	3. 3	3	29	0	Cloſe.
	14	1. 3	3	27	N E 2	A very little Shower.
22	8	3.	6	27	N E 1	Cloſe, a little, very little Snow in the Afternoon, ☿ riſing.
23	8	3. 5	10	26	1	Clouds.
	17	2. 7	10	20	S W 1	Cloſe.
24	8	3. 5	29.14	24	S W 1	Very fair, little Snow and Hail about 12, the ☿ falling a little.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
25	8	2. 7	10	27	S W 2	Fair.
26	8	1. 6	2	35	3	Rain very little at Night.
	12		5		S W 4	Cloſe.
	18	1. 0	7	29	S W 2	Cloſe.
	24		7	34	1	Hard Rain, the ☿ a little fallen.
27	8	1. 0	7	37	W S 2	Cloſe.
	17	0. 2	2	33	W 1	Small Rain.
28	7	0. 7	12	33	W 1	Cloſe.
	16	0. 5	12	30	W 1	Fair.
29	8	1. 6	10	32	W 1	Rain. Rain a great deal laſt Night.
	13		8	2	N 1	Cloſe, miſling Rain all this Morning till now.
	15		7		N 1	Cloſe.
	22	1. 6	5	31		Fair.
30	8	2.	1	32	W 2	Cloſe Rain laſt Night.
	15		2		N W 3	Rain as almoſt all this Morning.
	19		3		N W 3	Rain gently, as the great Part of this Afternoon.
	24		6			Fair.
31	9	3. 1	6	29	N W 1	Fair.
	24		3			Cloſe, Rain in the following Part of the Night.
April. 1	9	2. 6	2	52	S 1	Small Rain.
	24		1			The greateſt Part of the foregoing Day gentle Rain.
2	9	1. 7	28.16	39	S E 2	Cloſe, Rain a great deal laſt Night, ſo as to make a Flood.
	16	1	17		S W 2	Fair.
	24		19			Cloſe, Rain in the following Part of the Night.
3	9	2. 2	29. 0	23	N 2	Cloſe.
	14	1. 7	2	32	N W 3	Small Rain.
4	8	3. 4	10	30	N 2	Fair.
5	8	3. 2	19	26	N W 1	Cloudy.
	14	2. 1	19	26	N W 1	Rain, the ☿ a little riſen, the Rain laſted about an Hour.
	14	2. 1	19	26	S E 1	Rain.

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
	17	2. 1	19	26	S E	1	Rain.
6	8	3. 2	30. 3	27	N E	1	Cloudy.
7	8	3. 0	4	25	N	1	Fair.
	3		2	25			Cloſe.
8	8	2. 4	2	23	N E	1	Cloſe.
	24	1. 7	1	22			Cloſe.
9	8	2. 0	29. 19		N E	1	A little Fog.
10	9	3	30. 0	21	N E	2	Fair, $\frac{13}{16}$ | 23 $\frac{16}{16}$.
11	8	4	2	17	N E	1	Not a Cloud 16 | $\frac{15}{16}$.
12	8	2	1	12	N E	1	Scarce a Cloud 15 | $\frac{9}{14}$.
13	8	1. 4	34. 0	7	N E	1	Not a Cloud.
	13	0.—2	29. 19	3	E	1	Not a Cloud, but a thick Air called a red Wind.
14	8	1.—0	16	10	N E	1	High Clouds.
	3	0.—3	15	8			Clouds.
15	7	0.—3	15	9	N E	1	Very fair.
16	8	0	18	8	W	2	Very fair.
17	9	0. 3	17	6	S W	2	Very fair.
	23	0.—6	16	7			Small Rain for a little while.
18	19	0. 1	15	18	S W	2	Cloudy.

In the Cloſet on the North Side of the Houſe.

	15	0. 3	14	16	S W	2	Cloſe.
	23	0. 2	14	18			Rain.
19	9	1. 0	15	18			Fair.
	16	0. 5	15	16	S W	3	Cloſe.
20	9	0.—2	15	16	W	1	Fair.
	9	0.——	6	18	S W	2	Cloſe, a little Rain this Morning.
21	23	0. 4	1	27		2	Rain, as it had been moſt part of the Day.
22	8	1. 1	29. 0	17			
30	24	2. 3	4	21	N E	3	Rain, and all the Day before Rain.

May.

1	10	2. 2	8	29	N E	2	Cloudy.

In the Chamber on the South Side of the Houſe.

2	8	2. 1	12	29	N W	2	Cloudy, Rain laſt Night, ☿ was at 23 laſt Night as now.
	18	3	11	27		1	Fair, two or three Showers ſince 8.
3	9	2	14	29	N E	1	Fair.

The Weather in Eſſex.

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
4	11	1.	14	26	N W	1	Fair.
5	8	2. 6	16	23	N W	2	Cloſe.
6	8	6	16	24	N W	1	Fog.
7	8	0. — 2	14	21	W	1	Fair.
	19		13				Rain.
8	9	0 —— 3	17	16	N E	1	Cloudy.
9	8	0 ——	19	13	N E	1	Fair.
		2 1					
10	7	2. 2	19	12	N E	2	Fair.
13	17	0 —— 2	19	5	N E	2	Fair.
14	10	1. 0	19	12	N E	2	Fair.
15	9	0 —— 2	19	12	N E	1	Rain a little.
	16	0 —— 4	19	13	N E	1	A few Drops, the ☿ ſunk a very little.
16	7	0	17	13	E	1	Fair.
17	8	0 —— 4	29.14	8	N E	1	Not a Cloud.
18	7	0 —— 6	29.12	5	S	1	Clouds, a little Shower about 10.
19	9	0 —— 5	12	6	W	2	Cloudy, *i. e.* more Clouds than clear Sky.
20	9	3	10	5	S E	1	Cloudy.

N. B. Cloudy ſignifies more of the Sky cover'd than clear. Fair ſignifies more open Sky than cover'd with Clouds.

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
21	9	0	9	6	S W	1	Cloudy.
	18	0 —— 2	9	5	S W	1	Rain for about an Hour.
22	8	0 —— 1	12	6	N E	1	Cloſe, *i. e.* the Sky no where to be ſeen for Clouds; a Shower about 17.
23	6	0 —— 2	18	7	W	1	Fair, *i. e.* more Sky than Clouds.
	9	2	18	8	S W	1	Very fair.
	15	1. —— 1	18	7	W N	2	Hard Rain about ¼ of an Hour.
	17	1. 1	18	7	S W	2	Hard Rain.
24	7	0 —— 4	17	8	N E	1	
25	8	5	14	8	S E	1	
26	8	1. 1	10	6	E N	1	
	18	3	10½	8	N E	2	Cloſe, a Thunder Shower at 19 the ☿ being riſen to 11.

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
27	7	7	12	7	N E	2	Cloſe.
28	7	0 1	14	7	N E	2	Cloudy.
	12	0 7	14	9	N E	2	Cloudy.
29	8	1. 1	13	10	W	2	Cloudy.
	13	1. 3	13	10	W	2	Rain.
30	6	0 2	15	8	W S	1	Cloſe.
	11	0	13	8	S W	3	Rain till Night.
	14	0 1	11	9	S W	3	Rain.
	21	3	3	14		3	Rain hard.
	24	3	29.	17		4	Cloſe.
31	7	0 3	1	14	W	4	Cloudy.
	24		2		W	4	Cloudy.
	24	1	4	12		2	Fair.

June

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
1	7	0 4	6	12	W	3	Fair.
2	7	0	4	13	W	2	Cloudy.
	10	0 1	4	13	W	4	A Shower for about half an Hour,

and then fair and calm again, at 11 Rain again, the ☿ a little raiſed. Several Showers in this Day.

D.	H	Ther. 4	Bar.	Hyg.	Wind.		Weather.
3	8	0 ½	13	14	W	1	Cloſe.
	9	0	14	14	W	1	Rain a little.
4	6	0 2	14	13	S	1	Fair.
	23	0 5	7	13		1	Cloſe.
5	9	0	4½	13	S W	3	Cloudy.
	12	0 6	4	14	S W	2	Hard Rain ¼ Hour, ſeveral ſuch Showers this Afternoon.
6	7	0 5	29. 5	14	S W	1	Cloudy.
	10	0 3	5	14	S W	2	Hard Rain ¼ Hour.
7	7	0 3	6	13	S E	2	Betwixt Cloudy and Fair.
	11	0 1	6	13	S E	2	Hard Rain ¼ Hour, and a very great Shower 1 Hour, ☿ ſtanding as it was.
8	8	0 4	7	13	0		Fair. (all this Morn.
9	9	0 1	6½	15	W S	1	Rain a good part of laſt Night, and
	24	0 6	11	18		2	Rain all the Afternoon till 20 or 21, the ☿ all the while riſing, now cloſe.
10	9	0 4	12	18		0	Cloſe, Rain the paſt morning.

11

D.	H	Ther. 4		Bar.	Hyg.	Wind.		Weather.
11	9	0———		13	19	S W	2	Cloudy.
	11	0———	3	14	19	S W	2	Rain ¼ Hour.
12	9	0———	1	17	17	S W	2	Very Cloudy.
13	8	0———	7	17	19	W	1	Cloudy.
14	18	1	1	16		W	1	Cloudy.
15	7	1.	0	15	18	N	1	Very fair.

July.

In my Abſence, the Thermoſcope being obſerv'd, it was found from the 15th of *June*, to the 11th of *Auguſt*, never to get ſo high as 3, and was very often below Temperate; ſo cold was this Summer.

Auguſt.

13	19	2	6	29.10				Cloudy, Rain about 21.
14	9	1	5	29.10		S W	2	Cloudy.
	11	1	6	29.10	17	S W	2	Rain.
	23	1	0	12	17			Fair.
15	9	1	2	8	25	E	2	Cloudy, Rain laſt Night.
	12	1	5	7	26	S E	2	Rain.
16	8	0———	5	12	25	W	2	Fair.
17	8	0———	2	15	21	S E	1	Fair.
18	7	1	1	14	22	S W	1	Cloudy.
	24	2	1	13	22			Small miſty Rain.
19	9	1	4	15	22	W	2	Cloſe.
20	8	1	1	18	20	S W	1	Very Cloudy.
21	8	1	0	16	19	S	1	Fair.
	10	1	3	16	19	W	1	Very ſmall Rain.
	12	1	5	16		W	1	Very Cloudy.
22	8	1	6	18	18	N W	2	Fair.
23	9	0———	5	30. 0	16	S W	1	Not a Cloud.
24	8	0———	3	30. 0	15		0	Not a Cloud.
25	8	1	1	29.19	15	S W	1	Not a Cloud. (ſince Yeſterday Morn.
26	8	1	2	16		S E	1	Not a Cloud, ☿ gently ſinking ever
	17	3	5	16			1	Fair.
27	7	1	5	14	12			Thick Fog.
28	8	1	1	29.16	12	N W	2	Very fair.
29	9	0———	7	16	10	N W	1	Very Cloudy.
						rac. S E		

D.	H	Ther. 4.	Bar.	Hyg.	Wind.	Weather.	
	17	1. 3	15	12	0	Cloſe, ſome ſmall Drops.	
30	8	1 5	13	12	N W 2	Cloſe.	
	20	0. 0	12	13	NE 1	A little Rain.	
31	8	0 2	13	12	NW 1	Very fair.	
1	9	1. 0	11	23	S W 3	Cloudy.	*September.*
	12	1. 3	11	13	S W 3	A little Rain.	
	14	1. 4	11	13	S W 2	Hard Rain for 1 Hour, and ſoft till 17.	
2	3	0 2	14	11	W 2	Fair.	
3	9	0 6	14	10	W 2	Cloudy.	
4	8	2. 0	15	8			
5	8	1. 6	16			Very fair.	
18	22	0 6	29.11		W 2		*October.*
19	9	0	4		S 3	Rain.	
20	9	1 2	5		S W 2	Very fair.	
	18	0 3	2	16	S W 4	Rain.	
21	9	1. 4	10	17	W N 2	Not a Cloud.	
	24	0 5	15	16		Rain.	
22		0	16	37	W S 3	Cloudy.	
	16	0 3	17	33	W S 2	Cloudy.	
23	9	0 3	17	33	S W 1	Cloudy.	
	15	0 3	16	24	S W 1	Fair.	
24	9	0 5	15	27	S W 2	Fair.	
	14	0 1	16	30	S W 1	Small Miſt.	
25	8	0 5	30.	30	W 2	Cloſe.	
	15	0 3	29.19	29	W 2	Scarce a Cloud.	
26	9	0 5	16	28	W 1	Cloudy.	
27	9	1. 1	13	27	W 1	Cloſe.	
	23	0 7	13	27	1	Cloſe, a little miſling Rain good part of the Afternoon.	
28	9	1. 0	15	28	N W 1	Cloudy.	
29	9	1. 1	17	28	E 1	Cloſe, a little Fog.	
		0 7	18	29	E 1	Cloſe, a little gentle Rain about 15.	
30	9	2. 1	30. 1	26	E 2	Cloudy.	
31	8	3. 0	29.19	18	N E. 1	Fair.	
	11	2. 6	18	19	N E. 1	Hard Snow, which laſted till paſt Midnight.	

	D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
November	1	9	3. 5	29. 9	19	N E 1	Fair, ſcarce a Cloud.
	2	11	4. 0	7	20	S W 1	Froſt.
		15	3. 6	7	20	S W 1	Snow, which began at 13, and laſted to 20.
	3	9	3. 5	7	23	W 1	Cloſe.
		12	3. 0	5	25	W S 1	Rain, which began at 11, and laſted till 17.
		24	2. 0	1	39	3	Cloſe, Rain before 1, and ſo the greateſt Part of the Night.
	4	9	1. 5	3	40	S 2	Cloſe.
	5	9	1. 4	13	36	N E 1	Cloſe, Rain laſt Night.
	6	9	2. 0	15	33	N E 1	Cloſe.
	7	8	2. 2	16	32	N E 0	Cloſe.
	8	9	2. 1	14	32	E N 1	Cloſe.
		16	2. 0	14	33	N E 1	Rain, which began at 14, and continued till 24.
	9	9	2. 2	13	33	N 2	Small Rain but for a very little while.
	10	9	2. 4	17	32	N W 1	Not a Cloud.
	11	9	2. 4	17	30	W 1	A little Fog.
		16	1. 6	14	32		Hard Rain.
	12	9	1. 5	10	33	W 1	Rain.
	13	9	3. 1	4	30	W 0	Fair, Froſt.
	14	9	4. 2	12	28	N W 2	Very fair, hard Froſt.
	15	9	4. 6	16	26	W 0	Very fair, hard Froſt.
	16	10	4. 1	8	31	S 3	Cloſe, Snow laſt Night from 11 the greateſt Part of this Day.
	17	9	3. 7	8	34	S 1	Very Cloudy.
		1	3. 0	6	35	S W 2	Rain.
	18	8	4. 0	10	37	0	Fog, in the Cloſet on the North ſide of the Houſe.
	26	22	4. 2	18		3	Cloſe, in the Cloſet on the North ſide of the Houſe.
	27	10	4. 4	16	34	E 2	Cloudy.
	28	9	4. 6	18	32	E 3	Fair, Froſt.
	29	9	4. 6	16	31	E 3	Cloſe, Froſt.
	30	9	4. 5	18	33	E 3	Cloudy, Froſt.

December.

D.	H	Ther. .4	Bar.	Hyg.	Wind.	Weather.
1	9	4. 5	30. 0	33	E 2	Rain mix'd with Hail, the Rain as it fell, froze, and continued miſling till 14 or 15.
2	9	4. 1	30. 0	38	S E 2	Rain, which began laſt Night, and laſted all this Day.
	17	3. 4	29.17	39		Fog.
3	9	3. 6	19	45	S W 0	Thick Fog, Froſt.
4	9	2. 6	5	48	S 2	Rain all the Morning.
	12	2. 3	3	49	S W 2	Cloudy.
5	10	2. 4	5	54	S W 2	Cloudy.
6	11	2	7	53	W 2	Cloudy, ſome Rain this Morning.
7	9	3	3	54	W 2	Cloſe.
8	9	1. 4	18.18	56	S W 4	Rain and Stormy Wind all this Day.
	23	0	15	58	S W 4	Hard Rain.
9	9	4	16	55	S W 3	Cloudy.
	17	5	15	53	3	Hard Rain.
	24	2. 1	15	52	3	Fair.
10	10	2. 4	29. 1	5[illegible]	S W 1	Very Cloudy.
	24	3. 1	11	52	0	Very Fair.
11	9	3. 4	13	53	W 0	Very Fair.
	18	2	13	52	E 1	Very Fair.
12	10	3. 0	10	54	S 3	Cloſe.
	15	2. 6	6	53	S E 3	Rain a little and ſhort.
13	9	3	4	54	S E	Cloſe.
14	9	1. 6	5	56	S 2	Rain all Day.
	18	1. 4	3	57	2	Rain yet.
15	9	2. 0	11	56	W 1	Very Fair.
	15	1	13	56	W 1	Thick Fog.
16	9	4	11	54	S 2	Cloſe.
	15	2. 0	11	57	S W 2	Rain from 12.
7	9	1. 6	14	56	S W 1	Cloudy.

In my Chamber on the South Side of the Houſe.

	11	1	15	54	W N 1	Fair.
	17	4	17	49	W N 1	Fair.
8	10	2. 7	30. 3	43	E 0	Very Fair, Hoar Froſt.
9	9	3. 2	0	43	S 0	Miſt. A Miſt is when the Drops manifeſtly fall.

D.	H	Ther. 4	Bar.	Hyg.	Wind.	Weather.
20	8	2. 6	19.17	45	N E 0	Miſt, as it was all Day yeſterday.
21	9	4	12	46	S W 2	Cloſe.
	19	1	4	48	S W 3	Rain.
22	9	1	6	48	S 1	Not a Cloud.
	24	5	0	42	3	Rain.
23	9	3	28.10	51	W 4	Rain, which had been all Night.
24	10	3. 2	19	45	W 1	Cloſe.
25	11	3. 3	29.12	40	W 1	Fair, Froſt.
26	9	2. 0	3	57	S W 3	Rain all laſt Night.
27	9	6	3	51	S 3	Cloſe.
	11	2	0	51	S W 4	Cloſe.
	12	1	28.19	51	S W 4	Rain all Day.
28	11	3. 2	18	48	S W 2	Rain.
29	9	6	29. 6	48	S 1	Fair, Froſt.
	24	2	28.19	47	S 4	Rain.
30	9	2. 3	11	57	W 4	Rain very hard all laſt Night till now.
	24	3	17	48	4	Fair.
31	9	6	15	46	W 4	Not a Cloud.
	20	5	29. 8	39	2	Rain.
	24	4	10	40	1	Cloudy.

Obſervations on the Weather, Rain, Barometer *for* 1699, 1700, 1701, 1702, *by Mr.* W. Derham. n. 286. p. 1443.

X. 1.] Mr. *Townley* having communicated to me an Account of the Weather, *&c.* I ſhall compare my Obſervations on that Subject, made at *Upminſter* in *Eſſex*, with thoſe which he made at *Townley* in *Lancaſhire*.

As to the moſt remarkable Weather, eſpecially Rain of 1702, and the Effects thereof: Mr. *Townley* tells me, that it is a general Complaint in the North of *England*, that there were but ſmall Crops of Hay, which Calamity befel the Southern Parts alſo; the Cauſe whereof may be perceiv'd by the following firſt Table of Monthly Rain; in which the growing Months of *March* and *April* appear to have been dry Months in *Lancaſhire*, and *May* no wet Month, conſidering the Quantities of the other Months, and of other Years. Here at *Upminſter*, *April* was fortunately a wet Month, till the 23d, or elſe, no doubt, we ſhould have ſuffer'd more than we did in the Want of Hay; for the growing Month of *March* was a dry Month, by the following Table; and *May* (which by the ſame Table ſeemeth to have had near a due Quantity of Rain) was a very dry Month: For very little Rain fell from *April* 23 till *May* 29, and then fell in great Showers, the greateſt Quantity of that Month's Rain. Mr. *Townley* doth not tell me Particulars, but I gueſs it to have been after this manner with them in the North of *England*; for beſides that *March* and *April* were dry Months with them, and *May* ſomewhat more wet; yet probably the Wet of *May* did not fall early in *May*; for it appears by the following Table the third, that the *Mercury* was high, and on ſomewhat a fix'd Station on *May* 13.

Thus much for the Weather in the Spring-Months of the Year 1702, and the Effects it had on Hay, which Effects I have ſome reaſon to think extended to many Parts of this Kingdom.

As to the other Months, there is little remarkable, beſides the vaſt Diſproportions of Rain between *Lancaſhire* and *Eſſex*, which I ſhould ſcarce take notice of, if it was not what happeneth almoſt every Year, as will appear by the following Table the firſt: The Cauſe of this I cannot judge of, unleſs it be that *Lancaſhire* is a more hilly Country than *Eſſex*, which ſort of Lands, as they more need Wet than Vales and low plain Countries do, ſo have greater Shares of it than theſe have; and perhaps ſomething may be attributed to the Weſtern Situation of *Lancaſhire* near the Sea; from which Quarter the Winds in *England* blow more than from the Eaſtward.

At the Foot of the Table of Rain, beſides the Quantity which fell in each Year, I have added the Depth thereof in Inches; or what Depth it would have been of, if the Earth had not imbib'd it, but it had ſtagnated on the Surface thereof.

I have added two Tables more, of the Stations of the *Mercury* in the *Barometer* at *Townley* in *Lancaſhire*, and at *Upminſter* in *Eſſex*, with the Differences thereof; and this obſerv'd at three times of the Day, *viz.* in the Morning, and about three in the Afternoon at *Townley*, but at Noon at *Upminſter*, and at nine a-Clock at Night. One Table to the firſt Day of every Month; the other the moſt remarkably low, high and more ſettled Stations of the ☿ the laſt Year 1702.

The Mercury *riſes and falls in* all Places *at the* ſame Time, *but not in the* ſame Proportion.

By theſe *Barometrical* Tables it may be ſeen how far true that Opinion is of ſome learned Men, *viz. That the ☿ aſcendeth and deſcendeth in all Places at the ſame Time, and in the ſame Proportion.* It is manifeſt, that the ☿ doth commonly riſe and fall in one diſtant Place, when it doth ſo in another, but not alike: Alſo when any conſiderable Variation is in one Place it is ſo in another; when remarkably high, remarkably high; when low, low; when a great Aſcent or Deſcent, generally the ſame elſewhere; but only the Differences of all theſe are not in equal Proportion in all Places; all which ſeemeth reaſonable to be expected, by reaſon of the Difference of Weather in different Places, eſpecially as to wet and dry.

A remarkable Deſcent *of the* Mercury.

There is one thing more in the following third Table, which I think deſerves Remark, becauſe I believe it to be the moſt conſiderable Alteration of the Mercury, that hath ever happen'd ſince the Invention of the *Baroſcope*, and that was the Deſcent on *Febr. 3d* and *4th* 1702; concerning which, Mr. *Townley* in a former Letter gives me this Account, "That on *Febr. 3d* the ☿ was at three in the Morning at 29. 15. at "3h. 28. 50. and at 10 at Night at 27. 5. The next Day it fell yet "lower, and about 12 was at the loweſt, *viz.* 27. 39; but for an Hour "before, and as much after, it varied only ſo much as to make it ſen"ſible that it was fallen, and began to riſe again; the loweſt he had "ever ſeen it before was on *Nov.* 18, 1674, when it fell to 27. 63. "That Mr. *Flamſteed* at the Obſervatory obſerv'd as remarkable a De"ſcent of his ☿; and that it happen'd about the ſame Time of the "Day, *viz.* two of the Clock in the Afternoon at both Places.

And *laſtly*, he tells me, "That the Deſcent in *Febr.* laſt was the "greateſt that has been ſince the filling his Tube, which was in *March* "1665." The Particulars which I obſerved here at *Upminſter* about that Deſcent were, That on *Febr.* 2 the ☿ was high, *viz.* 29. 80. the next Morning 29. 50. at Noon 29. 16. at Night 28. 43. the next Morning, (*viz. Febr.* 4.) at ſeven of the Clock, it was fallen to 28. 5. and was globoſe, as if it had riſen, or was inclin'd to riſe: But it continu'd in the ſame Station till Afternoon, and then began to riſe about two of the Clock, and roſe haſtily. The Weather accompanying was fair on *Febr. 3d* in the Morning, hazy at Noon, and Rain at Night, and a violent Tempeſt in the Night, and all the next Morning, of *Febr. 4th.*

TABLE I.

A Table, ſhewing how many Pounds, and Centeſimals of a Pound *Troy* of Rain, fell at *Townley* in *Lancaſhire*, and at *Upminſter* in *Eſſex*, in each Month of the Years 1699, *&c.* with the Quantity and Depth every Year.

	1699		1700		1701		1702	
	Townl.	*Upmr.*	*Townl.*	*Upmr.*	*Townl.*	*Upmr.*	*Townl.*	*Upmr.*
Januar.	17 91	8 91	20 84	3 91	22 41	14 96	21 10	9 81
Febru.	32 70	60 5	19 12	7 64	16 78	8 78	21 27	7 30
March	17 92	5 63	7 58	1 55	7 10	3 91	2 48	2 37
April	10 47	3 44	18 65	7 60	6 11	1 43	5 34	10 90
May	4 00	2 67	17 92	6 91	19 67	9 11	8 81	6 49
June	10 37	40	13 15	7 60	11 34	5 79	23 00	13 46
July	16 51	6 36	15 26	4 24	17 58	9 49	25 31	43 09
Auguſt	19 77	8 57	12 05	8 14	23 66	6 57	20 12	6 88
Sept.	16 53	8 06	23 52	14 85	21 30	5 63	23 01	8 05
Octob.	18 90	13 49	26 44	17 15	24 59	10 21	28 57	7 92
Nov.	14 65	1 91	13 69	5 24	25 60	8 22	37 11	14 05
Dec.	16 78	5 77	26 88	10 30	10 19	9 35	41 63	10 27
Total	196 51	75 55	215 30	95 13	206 33	93 45	257 75	101 89
Depth	39 302	15 110	43 060	19 026	41 266	18 690	51 55	20 378

TABLE II.

A Table ſhewing the Height of the ☿ at *Townley* and *Upminſter*, on the firſt Day of every Month in the Year 1702, three times a Day, *viz.* about 7 in the Morning, and 9 at Night; and about 3 Afternoon at *Townley*, with the Difference of the ☿'s Variation, and its Difference between both Places.

Firſt Day of the Month.	☿ Height at Town.	☿ Height at Upmr.	Daily Differ. at Town.	Daily Differ. at Upmr.	☿ lower at Town.
Jan.	29 06	29 28			22
	28 90	21	16	07	31
	58	10	32	11	52
Feb.	29 58	96			31
	40	91	18	05	51
	30	80	10	11	50
Mar.	36	68			32
	36	66	00	02	30
	40	58	04	08	18
April	70	79			09
	68	73	02	06	05
	69	79	01	06	10
May	20	51			31
	49	49		02	
	09	44	11	05	35
June	56	78			22
	61	82	05	04	21
July	84	98			14
	90	30 01	06	03	11
	92	11	02	01	19
Aug.	62	29 80			18
	49	74	13	06	25
	47	67	02	07	20
Sept.	92	30 09			17
	95	12	03	03	17
	95	11	00	01	16
Octob.	56	29 74			18
		76		02	
	54	75	02	01	21
Nov.	46	71			25
	50	75	04	0.	25
	58	76	08	01	18
Dec.	35	50			15
		34		16	
	10	09	25	25	01

TABLE III

A Table ſhewing the *Loweſt Stations* of the ☿ in the Year 1702, at *Townley* and *Upminſter*; with the Difference of the ☿ at both Places

Day of the Month.	☿ at Town.	☿ at Upmr.	Differ.
Feb. 3	29 15	29 50	35
	28 50	16	66
	27 50	28 43	93
		05	
4	39	05	66
		62	
Dec. 23	77	18	31
	71	12	41
	90	10	35
		25	
High Stations of ☿ An. 1702.			
	Upmr.	Town.	
Jan. 30	30 25	29 95	30
	25	95	30
	19	83	36
Mar. 12	33	30 02	31
	35	05	30
	32	07	25
Oct. 21	07	29 94	13
	18	99	19
	22	30 00	27
More ſettled Stat. An. 1702.			
	Town.	Upmr.	
Apr. 27	30 04	30 13	09
	00	15	15
	02	16	14
	03	16	13
28	01		
	29 99	15	16
	98	15	17
29	93	13	20
	86	06	20
May 1	78	29 89	11
	72	8	15
	74	87	13
June 10	30	68	03
	40	71	31
	44	70	26
11	50	70	20
	51	72	21
	59	70	11
ug. 30	45	86	41
	57	86	29
	59	88	29
ept 27	73	91	18
	72	91	19
	73	91	18
	74	91	1

2.] *A Proſpect of the* Weather, Winds *and* Height *of the* Mercury *in the* Barometer, *on the* firſt Day *of the* Month; *and of the whole* Rain *in every* Month *in the Year* 1703, *and the Beginning of* 1704. *Obſerv'd at* Townley *in* Lancaſhire, *by* R. Townley, *Eſq*; *and at* Upminſter *in* Eſſex, *by Mr.* W. Derham.

Obſervations *on the* Weather, *&c.* 1703, 1704, *by Mr.* W. Derham. n. 297. p. 1877.

The Mon.	*Weather at* Town.	*Weather at* Upmin.	*Winds at* Town.	*Winds at* Upminſt.	*Barom. at* Town.	*Barom. at* Upm.	*Rain at* Town.	*Rain at* Upm.
Jan.	*Overcaſt*	*Overcaſt*	S E 5	S E 1	29 04 28 91 80	29 39 35 22	15 17	8 89
Feb.	*Overcaſt*	*Froſt and fair*	S S E 3	E 1 *Clouds.* S	29 29 37 47	62 68	15 88	6 41
Mar.	*Chequer'd*	*Froſt and fair. Snow*	W S W N E	N W 1	64 67 73	82 83 92	20 02	4 75
Apr.	*Chequer'd and Cloudy*	*Fair* *Cloudy* *Fair*	W	W S W 1 W 4	59 59 55	93 91 91	17 63	12 49
May	*Cloudy*	*Cloudy Thunder with Hail and Rain*	N N E	NW *by* N 3 N *by* W 3	49 00 60	66 70 76	17 64	20 77
June	*Cloudy*	*Cloudy* *Clear*	S	S 0 S 1	38 49 63	61 75 88	24 06	14 55
July	*Cloudy*	*Fair*	SSE. SE E 1	E 1 N *by* E 2	84 80 77	99 96 90	3 65	14 90
Aug.	*Cloudy*	*Thunder and Rain* *Fairer*	S E 1 4 4	N 2 N *by* W 2 *Clouds.* SE	57 55 58	72 72 69	14 21	3 36
Sept.	*Clear* *Chequer'd*	*Cloudy* *Fairer*	E	W N W 1 N W 1	80 00 18	30 40 40	32 40	14 86
Oct.	*Chequer'd*	*Fair*	N	N N W 4	28 76 83 86	87 30 08	7 04	9 55
Nov.	*Overcaſt*	*Cloudy*	E	N *by* E 1	29 57 51 52	29 72 69	28 56	7 27
Dec.	*Overcaſt* *Cloudy*	*Overcaſt* *Rain*	W 3		36 45 48	81	10 24	2 14
							196 60	119 94

The Mon.	*Weather at* Town.	*Weather at* Upmin.	*Winds at* Town.	*Winds at* Upminſt.	*Barom. at* Town.	*Barom. at* Upm.	*Rain at* Town.	*Rain at* Upm.
170¼ Jan.	*Overcaſt*	*Overcaſt*	S S E S E 2	E 0 SE *by* E 1	80 82 85	30 07 10 10	31 39	4 06
Feb.	*Overcaſt*	*Miſling* *Cloudy*	W	NW *by* N 1	90 02 02	23 26 26	5 93	2 19
Mar.	*Overcaſt*	*Overcaſt* *Fairer*	S	SE *by* E 0 S E 1	29 11	29 58 45 40	20 78	16 04
Apr.	*Cloudy* *and* *Chequer'd*	*Rain* *with hail* *Fair*	W 4 N W 7	S *by* W 4 *Clouds* S W *by* W	28 72 94 07	17 18 38		

From theſe Tables it is to be obſerv'd,

1. That much more Rain falleth at *Townley* than *Upminſter*.

I have an Extract of the Rain at *Paris* and *Liſle*, as far as the *French* have publiſh'd their Obſervations. And by comparing the Rain of one Place with that of another, I find that there is about twice as much Rain falleth at *Townley*, as doth either at *Upminſter*, *Paris*, or *Liſle*. Mr. *Townley* hath formerly obſerv'd, that as much more Rain falleth at *Townley* as *Paris*. And M. *de la Hire* obſerves, that more Rain falleth at *Liſle* than *Paris*. But *Townley* doth far exceed.

At *Liſle*, one Year with another, the Depth of the Rains amounts to 22 Inches 3 Lines, *Paris* Meaſure, or 23 in 3 *l.* which make about 23⅛ Inches *Engliſh*, or 24½. At *Paris*, one Year with another, they amount to 20 Inches 3½ Lines *Paris* Meaſure, which is near 22 Inches *Engliſh*. But at *Townley*, one Year with another, according to Mr. *Townley*'s Computation formerly, the Rains amount to above 41 Inches Depth. And by taking eight other Years, in which the Rain was obſerved both at *Townley* and *Upminſter* (*viz.* from 1696 to 1704) I found that all the eight Years Rain at *Townley* amounteth to above 1700 *l.* *Troy*, at *Upminſter* 823 *l* only. Which ſaid Sums being divided by 8, give 212 *l.*½ one Year with another, at *Townley*, and 103 *l.* at *Upminſter*. Each of which Sums being doubled, and making a Decimal Fraction of the laſt Figure, doth nearly give the Number of Inches, which all the Rain would have riſen to, if the Earth had not ſwallow'd it up, *viz.* 42½ Inches at *Townley*, and about 20½ Inches at *Upminſter*. Wherefore the Rain at *Upminſter* is leſs than at *Paris*, at *Paris* than at *Liſle*, and at every one of the Places leſs than at *Townley* by much. The Reaſon of which vaſt Surmount at *Townley*, is doubtleſs from the Height of the Hills thereabouts, which retard or ſtop the Weſterly Clouds: From which Point the Winds blow more than any other here in *England.* But,

2. Notwithſtanding the great Diſproportion of Rain between one Place and another, yet there is a great Agreement between our Barometers; one riſing or falling when the other doth; and that much, or little, as the other doth; altho' not always ſo exactly in the ſame Proportion.

And this is what I find Monſieur *Maraldi* hath obſerv'd, by comparing his Obſervations at *Paris* with mine at *Upminſter*, in the Years 1697 and 1698. Only at *Paris* the ☿ is commonly three or four Lines ower than at *Upminſter*. And ſo it appears to be at *Townley*, from this and ſome other Tables, *viz.* three or four Tenths of an Inch lower at *Townley* than an *Upminſter*. Which is an Argument that *Townley* and *Paris* are ſituated higher above the Surface of the Sea than *Upminſter* which is nearly in the ſame Level with *London*) is.

3. There is ſome Agreement between the Winds at *Townley* and *Upminſter*. Which altho' not always exactly in the ſame Point, yet do often tend the ſame way, blowing within a Point or two perhaps of the ſame Courſe; eſpecially when the Wind is ſomewhat ſtrong. Or if the Winds have differ'd, yet the Scudd (as the Seamen call the Current of he Clouds) hath commonly ſhown the Motion of the upper Air to agree hereto.

This doth often happen, tho' not always. And this Monſieur *Maraldi* hath obſerv'd at *Paris* in the aforeſaid Years, *viz.* "That there are ' a great many Days, during the different Seaſons of the Year, where ' the Winds are the ſame in both Places, [*i. e. Paris* and *Upminſter.*] ' When the Wind was the ſame, both in one part and the other, it ' was ordinarily pretty ſtrong, and of long Continuance. And alſo ' he obſerved that the Winds had changed alike in both Places. *Vid. Hiſt. de l'Acad. Roy. des Sciences, An.* 1699.

Tables *of the* Weather, &c. *for* 1705, *by the* ſame. n. 309. p. 2378.

JANUARY. 7 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Froſt Fair Cloudy	N b W o 1	N E	30 14 17 16	79 90 87	
10	Froſt with thick Air	W o E b S o		21 22 25	82 93 87	
15	Hard Froſt and cloudy Thaw	W b N 1 S W o		00 29 97 93	74 85 95	
20	Froſt and fine Weather	E 1 E b S 1		30 03 06 13	73 96 82	
25	Miſt Brighter Cloudy	E b S 1 E S E 1		29 79 80 81	92 103 92	0 36
30	Cloudy Snow Cloudy	N 1 N b E 1	N b E	30 03 02 22 99	87 97 90	I. 1 11

FEBRUARY. 7 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Rain	S 2 S E b S 2		28 89 77 78	98 102 93	2 68
10	Fair Cloudy Rain	S S E 1 S 5	S W b S	29 85 81 66	97 115 107	
15	Froſt Sun-ſhine with thin Miſt	N b W o		30 39 31	84 88	
20	Miſty Cloudy	E b N 2		03 29 97 86	92 100 95	
25	Froſt Fair Rainy	S b E 1 S 2	S S W	28 27 19	81 115 95	
30				The Sum of the Rains		I. 5 53

MARCH. 6 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Cloudy	N N E 3	N E	29 61	94	
	Fair			65	90	
10	Froſt	S 0	W b N	41	86	
	Sun-ſhine	E N E 1		40	112	
	Cloudy			40	90	
15		E 1	S	24	94	
	Rain					
				17	105	
20	Dark with Storms of Snow	N b E 2		65	88	
25	Brighter with ſmall Snow	N b W 2		21	83	
				33	104	
				48	81	
30		S b W 3		35	116	
	Turbid and rainy	S W 8		30	127	1.
				22	108	5 55

APRIL. 5 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Cloudy	W S W 1		29 72	102	
	Dirty	S W 5		70	122	
	Drops			66	120	
10		E b N 1	S b W	34	98	
	Rainy			32	117	
				25	106	
15	Froſt with	N 0		82	79	
	Sun-ſhine			90	116	
	Cloudy			96	98	
20	Cloudy	W b S 1		91	101	
		W 2		92	134	
	Milder			85	120	
25	Hoar-froſt	W 0	N b W	70	86	
	Thunder with	1	N b W	80	125	
	much Rain			87	117	
30		W b N 1		68	100	
	Fair and warm					1.
				73	109	5 15

MAY. 5 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.		Th.	Rain	
5		S W b S 1		29	61	115		
	A cloudy Day	S b W 2			56	150		
					55	120		
10	Cloudy	S S W 1	N W	30	07	104		
		W b N 2			05	142		
	Fair			29	98	124		
15	Showers of Hail	NWbN 2			80	92		
	and Rain							
					95	97	0	22
20	Cloudy	N 1			78	106		
		N b E 2			78	124		
	Fair				80	113		
25	Cloudy and	N b E 2	N N E		85	93		
	Cold	N 2			91	120		
	Clearer				96	101		
30		W b N 1			71	98		
	Cloudy and cold							1.
					85	99	2	03

JUNE. 5 . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.		Th.	Rain	
5	Cloudy and	S W 1	W	29	62	119		
	Warm	N N W 1	W N W		65	143		
	Dropping				64	126		
10	Sun-ſhine with	E S E 2		30	03	110		
	Heat	E b S 2	S E b S		01	153		
	Cloudy, Rainy			29	94	126	0	30
15	Miſt	W b S 1			92	127		
	Hot	2			92	152		
	Sun-ſhine				93	132		
20	Cloudy	E 1			95	125		
	Hot							
	Not ſo hot				94	125		
25	Cloudy	SWbW 2			62	137		
	Drops	W 3			59	151		
	Showers				50	131	0	08
30	Miſt	N 0			84	106		
	Sun-ſhine	W 1			62	156		1.
	Hot				04	134	3	29

JULY.

5 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Sun-ſhine	W 0	N W	30 08	122	
	Rain	N W 2		08	139	
				10	116	0 82
10	Cloudy	N b W 3		29 79	112	
	Showers and not	5		88	120	
	ſo hot			30 80	118	
15	Sun-ſhine	E b S 0		29 96	112	
	Very hot	S 2	N	93	163	
				90	145	
20	Sun-ſhine with	S W b W 0		30 03	115	
	Heat	N N W 2		03	164	
	Cloudy			03	136	
25	Sometimes Sun-	W b S 0		29 72	110	
	ſhine, ſometimes	S b W 3	W	69	170	
	cloudy			66	148	
30	Sun-ſhine	W b S 1		79	116	
	Cloudy	S W 2		82	151	1.
	Leſs cloudy			82	135	5 56

AUGUST.

5 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Cloudy	W S W 1	W	29 80	133	
	Leſs cloudy	W b N 1		86	158	
				86	148	
10	Sun-ſhine	S S W 3	S W	48	131	
	Windy	S W 6		56	158	
	Miſty			44	138	1 00
15	Thick	S W 0		97	109	
	Cloudy	S S W 1		94	153	
				82	132	
20	Sun-ſhine	S 1	S W	61	120	
	Drops					
	Leſs cloudy			65	129	
25	Sun-ſhine	W 1	N W	34	105	
	Drops	W N W 6		42	128	
	Leſs cloudy			49	117	0 07
30		S 1	S S W	68	127	
	Much Rain	S b W 4		71	142	1.
				74	124	10 81

SEPTEM.

SEPTEMBER.						6 ... 12 ... 9	
	Weather	Wind	Courſe of the Clouds	Barom.		Th.	Rain
5	Sometimes Sunſhine, ſometimes cloudy	S W b W o	W S W	29	88	107	
					88	144	
					84	118	
10	Cloudy	S S W o	S W above N W below		77	102	
	Showers				86	108	
15	Cloudy	W N W o	N b W	30	13	119	
	Miſty	W 1	N W		15	145	
	Cloudy				15	129	
20		E 1			25	124	
	Cloudy	E b N 4			25	138	
					22	128	
25		S W b S 1		29	36	110	
	Small Rain	S S W o			38	122	
					40	113	
30		N W o			48	93	
	Hoar-froſt and	W b N 1			50	112	I.
	Sun-ſhine				42	92	0 04

OCTOBER.						7 ... 12 ... 9	
	Weather	Wind	Courſe of the Clouds	Barom.		Th.	Rain
5	Sometimes ſhowers	S 1		28	93	111	
	ſometimes Sunſhine	S b W 2			99	127	
				29	10	111	0 56
10	Thick Miſt	S E o			93	101	
		E S E o			98	128	
	Sun-ſhine			30	05	108	
15	Cloudy	W S W 2	W	29	75	98	
	Sun-ſhine				78	108	
20	Sun-ſhine	S E 1		2	18	86	
	Cloudy	E b S 2	S E b E		16	112	
	Thunder, &c.	E N E 2			22	108	5 69
25		N 2			86	89	
	Sun-ſhine and cold	3			92	103	
				30	04	87	
30	Froſt with Sunſhine	N b E 2		29	94	87	
							I.
				30	00	89	16 01

NOVEMBER. 8 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Froſt and	E N E 1	E	29 68	83	
	Sun-ſhine	E b N 1		72	103	
	Cloudy			72	101	
10	Cloudy	S 2		80	103	
	Rainy	6		44	120	0 27
15	Froſty and Sun-ſhine			30 05	80	
20	Thick Miſt	N 2		29 57	89	
	Rain and	W 1		57	89	
	Turbid	9		35	98	0 91
25	Froſt and	W 0		65	79	
	thin Miſt			67	85	
				71	76	
30	Thin Miſt	S b W 2		10	102	
	Cloudy	4	S S W	10	112	1.
	Rain			28 84	111	5 84

DECEMBER. 8 . . . 12 . . . 9

	Weather	Wind	Courſe of the Clouds	Barom.	Th.	Rain
5	Sometimes cloudy,	W 2		29 10	92	
	ſometimes fair	W b N 3	N W	25	102	
				46	92	
10	Cloudy	N N W 1		45	88	
				61	89	
15	Small Rain	S W b W		34	100	
		W b S 3		36	101	
	Rain			31	95	1 21
20	Rain	S 1		28 73	94	
	Clear			73	100	
	Froſt			76	84	1 83
25	Cloudy	N b E 1		29 72	94	
	Rain		N N E	76	96	
	Snowy			90	88	0 48
30		S E b S 1		92	87	
	Dark	S E 1		90	88	1.
				86	85	21 70

In

Explication of the Tables. In theſe Tables I have ſelected only every fifth Day of every Month, which may give a commodious View of the whole Year.

Theſe Tables cannot want much Explication beyond their Titles, except in the Columns of Winds and Clouds, in which I have made uſe of the Marks in *Engliſh.* For their Variety was not known to the *Romans.*

The four principal Quarters are denoted by theſe Letters: N the North, S the South, E the Eaſt, and W the Weſt.

The intermediate Points are denoted by a Conjunction of theſe Letters; N W denotes the Wind which *Seneca* calls *Corus,* we the North-Weſt, which he ſays blows from the Weſtern Solſtice; S W *Africus,* or the South-Weſt; S b W, South and by Weſt, denotes that Point which lies next to the South; S S W, South-South-Weſt, the next to this; S W b S, South-Weſt and by South, the next to this, or that which lies between this and the South-Weſt: And ſo of the reſt.

The numeral Figures annexed to the Winds ſhew the Strength of the Winds. The Cypher 0 denotes the Tranquillity of the Air, or that no Wind blows: 1 denotes ſo mild a Wind, that it would hardly extinguiſh a lighted Candle: 2 is a ſtronger Wind: 7, 8, *&c.* as far as 15 or 20, denote more violent and raging Winds.

As to the Column of the Thermometer, it is to be obſerved, that the Degree of Freezing is about 85. But Hoar-froſt will happen about 90, or ſomething higher.

In the Column of Rain, ſometimes I have put down the Weight of the Rain that has fallen on the rainy Days mark'd in the Table. And at the End of every Month is ſet down the Quantity of all the Rain fallen in that Month. In this whole Year there fell 84,62 Pounds of Rain, of thoſe Pounds which we in *England* call *Troy* Weight.

The Funnel which receives the Rain is circular, the Diameter of which is equal to 12 *Engliſh* Inches.

Laſtly, Theſe Obſervations were made three times in a Day, except I was abſent or otherwiſe employ'd. The Hours of obſerving, both before and after Noon, are mark'd at the Top of each Month.

Remarks on the Weather. About the End of *February,* and the greateſt part of *March,* our People were generally ſeized with a Difficulty of Breathing, and a Cough. Let the Phyſicians judge whether this might not proceed from the Eaſtern Wind, together with a cold and moiſt Temper of the Heavens, which the Tables ſhew were then cold but not froſty.

Apr. 1. in the Morning *Parelia* were ſeen by ſome, but I did not happen to ſee them.

The Month of *June* was ſo hot and dry, that the Springs fail'd, the Fruits languiſh'd, and the Graſs was dry'd up. Honey-dews were alſo frequent. Likewiſe the Corn was blaſted.

Aug. 11. the Wind was ſo fierce, that it did great Injury to the Fruits of the Trees.

And though Plenty of Rain ſucceeded, yet the Ponds were dry in *September,* and there was a great Scarcity of Hay.

Dec.

December 19. This Morning (I think) was the greateſt Deſcent of the *Mercury* in the Barometer, in the following Manner.

8^h ¾ In the Morning	28,28 Inches.
10	28,06
11	27,94
11½	27,94
12½	28,03
1 Afternoon	28,13
1 10′	18
1 20′ Wind Weſt 7	20
2 Wind Weſt 9	34

The Changes of the Heavens and of the Weather were not ſo remarkable as thoſe of the *Mercury*. Only in the Afternoon the Wind was violent, and much Rain fell in the Night. But we heard that Day there was a dreadful Tempeſt at *Corbeil.*

This greateſt Deſcent of the *Mercury* was obſerved by others. In the Obſervatory at *Greenwich* the *Mercury* deſcended to 27,80 Inches; in the City of *Canterbury* to 27,90.

In the Reckoning of the Rain I had almoſt forgot to mention the Depth of the Rain. If the Earth had not abſorb'd it, it would have aroſe to 16,924 *Engliſh* Inches: Therefore this Year is to be accounted a dry Year: For the mean Proportion of Rain every Year is about 20⅔ Inches at *Upminſter*; and 42½ at *Townley* in *Lancaſhire*; alſo 22 at *Paris* in *France*, and 24 Inches at *Liſle* a City of *Flanders*, as I obſerved above.

XI. The Society having put into my Hands Dr. *Scheuchzer*'s Obſervations of the Weather, &c. made at *Zurich* in the Year 1708, and having received from Dr. *Mich. Angelo Tilli* the Quantity of Rain which he obſerved to fall at *Piſa*; I have compar'd theſe Obſervations with mine made at the ſame time at *Upminſter*; and have put what I could of them into the annexed Tables. In the former of which, I have repreſented Dr. *Scheuchzer*'s and my Barometrical Obſervations: In the latter, his Rain Obſervations, thoſe of Dr. *M. A. Tilli*, and mine own; all reduced to our *Engliſh* Meaſure. But becauſe I am not as yet certain of the true Proportion between the *Tuſcan* and *Engliſh* Weight, I have therefore given Dr. *M A. Tilli*'s Rain, both in the *Tuſcan* Pounds and Ounces, as he ſent it me; as alſo reduced to our *Engliſh Troy* Pound and Centeſimals of that Pound, according to Mr. *Greaves*'s Proportion, which is different from that aſſigned by Sir *Jonas Moor*.

Tables *of the* Barometrical *Altitudes for* 1708, *at* Zurich *in* Switzerland; *and of the* Rain *at* Piſa *in* Italy, *and* Zurich, *and* Upminmer, *for* 1707, 1708, *by Mr.* W. Derham. n. 341. p. 342. *With* Remarks *on the Winds, Heat, and Cold,* &c.

As for the *Thermometer*, it would have been in vain to have compared Dr. *Scheuchzer*'s Obſervations with mine, by Reaſon we have

Obſervations *with the* Thermometer.

not yet a Standard for Thermometers, as we have for the Barometers: they being every where in all, or moſt Reſpects different; ſome with ſmall Bottles of Spirits; ſome accordingly with longer, ſome with ſhorter; ſome with wider, ſome with narrower Canes or Shanks; ſome fill'd with more highly rectify'd, and conſequently more expanſive Spirits; ſome with more phlegmatic and duller Spirits.

The Difference particularly between Dr. *Scheuchzer*'s and my Thermometer is, his is about one Foot long; that I obſerved with all along ('till it was broken this Year) about two Feet and a half; and that I now obſerve with three Feet and a Quarter; the Bore of the Stalk is ſmall, and the Ball is large, and conſequently the Rang great, anſwering every the leaſt Alteration of Heat and Cold.

But yet, thus much I have been able to obſerve by comparing Dr. *Scheuchzer*'s and my Thermometrical Obſervations, *viz.* That notwithſtanding the *Alpine Snows* have mighty Effects on the Weather in *Switzerland*, and other conterminous Places, yet there is much more Agreement between the Heats and Cold at *Zurich* and *Upminſter*, than before comparing them I imagin'd. (I ſpeak with relation to the laſt Year only, having no other Obſervations.) For in Winter, altho' I imagine we have more warm Days than they; and in Summer, that they have greater Heats than we; yet I obſerve that the Colds and Heats in both Places, begin and end nearly about the ſame Time: And that oftentimes any remarkable Weather (eſpecially if of ſomewhat long Continuance) affecteth one as well as the other Place. Thus, for Inſtance, *June*, which was (ſome part of it at leaſt, particularly the very Day after the Solſtitial-Day, *June* 12.) remarkably cold in *England*, ſeems to have been not very different at *Zurich*; Dr. *Scheuchzer*'s Thermometer divers Times that Month (tho' not on the very ſame Days perhaps) deſcending as low, or rather lower than in the Month before, yea, as many Days in the Winter Months. I obſerved too, that all this Month their cold Weather conſtantly preceded ours here about five or more Days. An Indication that the Weather in both Places was influenced by the ſame Cauſes, whether from the *Alpine* Hills and Cold, or the Influx of the Moon and other heavenly Bodies, or any other Cauſe.

And as in *June* there was a great Agreement in the unuſual Cold, ſo in *Auguſt* there was not much leſs Agreement in Heat; the Heats in both Places being great, and beginning to abate about the ſame Time, only a little ſooner here than there.

In Winter alſo, although I imagine we have a greater Number of warmer Days than they, yet I find that a warm Winter Month there is ſo here; and a cold one there, is a cold one here likewiſe. Thus in *February* and *March*, *October* and *November*, a great Agreement ſeems to have been between the Heats and Colds of both Places, ſome Days excepted. But *January* was at the Beginning not ſo conſtantly cold, for the Seaſon at *Upminſter*. as it ſeems to have been at *Zurich*. And *December* laſt, which from the eighth Day to *Chriſtmas*-Day, was here moderate and open Weather, and after that more intenſely cold than even in the *Long-froſt*, *Anno* 1683, by the fewer Thermometrical Obſervations which Dr. *Scheuchzer* made then, than in other Months, the greateſt part of that Month ſeems to have been intenſely cold at *Zurich*, as the latter part thereof was with us remarkably in *England*.

—*of the* Winds.

As to the *Winds*, which I did not enter into Tables, becauſe it may be ſufficient to obſerve in general, that although many Days they agree in both Places, yet there are many more in which they differ. When they do agree, I find it is chiefly when the Winds are ſtrong, and of long continuance; and more, I think, when Northerly and Eaſterly, than in the other Points. Alſo, I have obſerv'd, that a ſtrong Wind in one Place hath been a weak one in the other.

—*of the* Barometrical *Obſervations*.

As to the *Barometrical Obſervations*, I have thought it worth while to ſpecify them. Mine own Obſervations I ſelected, which were made at Noon; and Dr. *Scheuchzer*'s as near Noon as might be. For which reaſon, I commonly took his Morning Obſervations, becauſe made, for the moſt part, about ten or eleven a-Clock. Alſo I took thoſe made with his bent Barometer; becauſe they ſeem'd to me (eſpecially at the beginning of the Year) to be the moſt accurate.

The Altitudes of this *Mercury* he meaſureth by the *Paris* Foot, which I have reduced to our *Engliſh* Meaſure; for which reaſon I have alſo all along noted their Differences.

It is manifeſt from the Tables, that throughout the whole Year, the *Mercury* was lower at *Zurich* than at *Upminſter*, by ſometimes one, ſometimes above two Inches *Engliſh*. The moſt remarkable Difference was at the latter End of *September* and Beginning of *October*, when the Difference was for a good while above two Inches *Engliſh*. The reaſon of which, I gueſs, was becauſe at *Zurich*, I imagin'd the Air was more inclin'd to wet, at that Time, than at *Upminſter*; as alſo, becauſe the Winds were then at Northerly and Eaſterly with us, which, 'tis well known, do make our Barometers riſe, even in our wet Weather. But the mean Difference between Dr. *Scheuchzer*'s and my Barometers, I take to be about half an Inch *Engliſh*. From whence I conclude, that the Situation of *Zurich* is near a Quarter of an *Engliſh* Mile higher than that of *Upminſter* above the Surface of the Sea; or elſe that that Part of the terraqueous Globe, lying nearer the Line, is (according to the receiv'd Opinion) higher, or farther diſtant from the Center, than ours is, lying nearer the Pole.

It may be obſerved from the Barometrical Tables, that (as near the Equinoctial the Barometer is obſerved to ſtand nearly at a Stay, but the more Northerly the Latitude, the greater the Rang of the *Mercury*, ſo) at *Zurich*, the Difference laſt Year was not ſo great between the higheſt and loweſt Stations of the ☿, as it was either at *Paris* or *Upminſter*.

For at *Zurich*, the Difference was only one Inch *Paris* Meaſure; at *Paris*, Dr. *Scheuchzer* ſaith, 'twas one Inch two Lines and an half; but at *Upminſter* it was eighteen Inches, (and ſome Years it is more) which is greater than either of them.

I obſerve, although there be ſome, and that a pretty deal of Agreement between the riſing and falling of our Barometers, one being very often high or low, when the other is ſo; and one oftentimes riſing or falling when the other doth ſo; and one riſing much or little, or falling much or little when the other doth; yet it is not ſo certainly ſo, as it is nearer home. I have before given a Table of ſome Heights of the *Mercury* obſerved at *Upminſter*, and at 200 Miles diſtance in *Lancaſhire* at the ſame time. And in the *Hiſt. de l'Acad. Roy. des Scien. Anno* 1699. Monſieur *Maraldi*, by comparing his Obſervations at the *Paris Obſervatory* with mine at *Upminſter*, takes notice, "That there "is a great Agreement between the Variation of the Heights of the "Barometers in both Places; that he finds almoſt always that when "one riſeth or falleth, the other doth ſo too, although not always "alike: That the Days in each Month whereon the *Mercury* hath been "higheſt or loweſt, it hath been the ſame at *Paris* as at *Upminſter*, but "ordinarily ſomewhat more than three or four Lines lower at *Paris* "than *Upminſter*." But the Agreement between the Variations of Dr. *Scheuchzer*'s Barometers and mine, although often great, yet is not ſo conſtantly, nor ſo certainly great as nearer home, *viz.* at *London*, *Lancaſhire*, *Paris*, and other Places, with which I have made the Compariſon.

—*on the* Rain. The Rain was obſerved at *Piſa* in *Italy*, by Dr. *Mich. Angelo Tilli*; and at *Zurich* in *Switzerland*, by Dr. *J. J. Scheuchzer*, and by myſelf at *Upminſter* in *Eſſex*.

The Rains for the moſt part are more frequent at *Upminſter*, that either at *Zurich* or *Piſa*; I mean, we have more Rainy Days than they. But yet the Rains in both theſe Places are much greater in Quantity, in the whole Year, and in ſome Months, eſpecially the Autumnal and Winter Months, than our Rains are at *Upminſter*. *May*, *June*, and *July*, and a great part of *Auguſt*, in 1707, ſeem to have been very dry, and I ſuppoſe ſearching Months at *Piſa*, as in ſome meaſure ſome of them were here: And in that Time leſs Rain fell there than here. But the following Autumnal Months made at *Piſa* ſufficient Amends, either by the great Quantity that fell at a Time, I ſuppoſe in Thunder, or ſuch like haſty large Showers; or elſe by the Quantity and Frequency of both. What a prodigious Quantity was that, for inſtance, of above 32 Pounds on *Auguſt* 19? (If it all fell on that, and not ſome on the preceding Days). But we find very large Quantities at a time to have fallen on divers Days, where it is manifeſt the Rain was weighed every Day, *viz.* ten Pound, nine Pound, and other large Quantities for ſeveral Days together, in the cooler Autumnal Months. But as the Weather groweth warmer, I imagine their Rains at *Piſa* are fewer; and what falleth, falleth in large Quantities. For which reaſon the Quantity of Rain in the Spring Months of *March*, *April*, and *May*, 1708, (oftentimes dripping Months in *England*) is nearly the ſame both at *Piſa* and *Upminſter*.

As to the Rain at *Zurich*, I obſerve, that altho' their Rains are leſs frequent than ours in *Eſſex*, yet they ſeem to be more frequent than theirs at *Piſa*: But the Quantity at *Zurich* is greater than at *Upminſter*, and leſs than at *Piſa*.

'Tis Dr. *Scheuchzer*'s Opinion, "That more Rain falleth in *Switzerland* than in *France*; at *Zurich* than at *Paris*." To confirm which, he giveth us this Table of eight Years Rain at *Paris*, to which I ſhall add mine for *Upminſter*.

The Rain at Paris *in eight Years.*						*At* Upm.	
The Year.	*Depth in Lines of* Paris *Meaſure.*	*Depth in Inches of* Paris *Meaſure.*		*Depth in* Engliſh *Inches & Centeſim.*		*Depth in* Engliſh *Inches & Centeſim.*	
		Inch	*Lin.*				
1699	224 ¼	18	8 ¼	19	93	15	11
1700	240 ½	20	½	21	37	19	03
1701	256 ¼	21	4 ¼	22	77	18	69
1702	196 ¼	16	4 ¼	17	45	20	38
1703	208 ¼	17	4 ¼	18	51	23	99
1704	238 ½	19	10 ½	21	20	15	80
1705	266 ¾	13	10 ¾	14	82	16	93
1706	183 ½	15	3 ½	16	31	24	29
Total Depth		142	10 ¼	152	36	154	22

It is manifeſt from this Table, that the *Zurich* Rain laſt Year (altho' it amounted not to the Quantity which fell at *Piſa* in a whole Year, yet) exceeded both the *Paris* and *Upminſter* annual Rains of eight Years before. But whether it conſtantly doth ſo or not, will appear from future Obſervations.

I take notice too, that there is a greater Difference between theſe laſt eight Years Rain at *Paris* and *Upminſter*, than I found in the eight Years, in which I formerly compared the Rain of *Townley*, *Paris*, *Liſle* and *Upminſter* together; for by that Compariſon it appeared, that leſs Rain fell at *Upminſter* than at either of the other three Places. But according to theſe later eight Years in the Table, a ſmall Matter more falleth at *Upminſter* than at *Paris*. For the mean Proportion for *Paris* (which according to former Years was above 20 Inches *Paris* Meaſure, or 22 Inches *Engliſh*) is according to theſe laſt eight Years, no more than 17 Inches, 9 Lines *Paris* Meaſure, or 19 Inches *Engliſh*: And *Upminſter* Rain, which I formerly computed at, Year by Year, about 20 Inches and an half *Engliſh*, is for theſe eight Years much the ſame, or a little more than that at *Paris*.

The Proportions therefore which I ſhall now lay down for the yearly Rain of all Places, whoſe Rain I have had Information of, are theſe; for *Zurich* ('till farther Obſervations are made) 32¼ Inches; for *Piſa* ('till farther Obſervations) 43¼ Inches; for *Paris*, 19 Inches; for *Liſle*, 4 Inches; for *Townley* in *Lancaſhire*, 42½ Inches; for *Upminſter*, 19¼ Inches; all the ſame, that is *Engliſh* Meaſure.

The laſt Obſervation I make is, the great Uſe of Cold to the making of Rain. That Exhalations and Vapours are the Matter of Rain, is not to be doubted; how they are raiſed, I ſhall not enquire; it is ſufficient for my preſent Purpoſe to ſay, that when thoſe Vapours are raiſed, they are conſtipated and condenſed into Clouds and Rain, chiefly by the Cold of the Air to which they are elevated. And the greater the Quantity of Vapours raiſed is, and withal the more intenſe the Cold of thoſe airy Regions, the greater is the Quantity of Rain. Now this is manifeſt from the annexed Tables, compared with Dr. *Scheuchzer*'s and my Weather, *&c.* Obſervations. Thus for inſtance *January*, which Dr. *Scheuchzer* frequently obſerved was ſometimes warm, ſometimes cold, and appeareth farther to have been ſo by his Thermometrical Column, and which was the ſame with us in *South Britain*, that Month, I ſay, had Plenty of Rain at *Zurich*, *Upminſter*, and *Piſa* too. The ſame might be ſaid of *February* for *Zurich*, and probably *Piſa* too. So alſo for *December* in 1707, at *Piſa* and *Upminſter*; and *December* laſt at *Zurich* and *Upminſter*. But with us *February* was for the moſt part a cold Month, and the Rain the leſs, by reaſon the Vapours either could not be raiſed in Plenty enough, or not be carried high enough, or ſuſpended long enough to be united, but ſoon were precipitated back again to the Earth.

From theſe Cauſes aſſign'd, the Plenty of Exhalations and Cold of the airy Regions, I conceiv'd it is, that at *Upminſter*, about the Equinoxes, we have often more Rain than at other Seaſons. But I cannot ſay this is certain and conſtant. Thus it was at the autumnal Equinox in 1707, not only at *Upminſter*, but at *Piſa* too: So at *Zurich*, *Piſa* and *Upminſter*, about the Vernal in 1708; and at *Zurich* and *Upminſter* the laſt autumnal Equinox: And this 28*th* of *March* 1709, is a pregnant Proof of this. For, not only unuſual Cold of the Winter hath been en ſucceeded by as unuſual Quantities of Rain all this Month, but at is very Time the Weather is open; but withal cool. Particularly *arch* 26, many Vapours aroſe, ſo as to fill the Air with a warm inking Fog. The Night following a ſmart Shower of Hail fell, a anifeſt Indication of the Cold of the Middle, or Top of the lower egion of the Air. And the Day after, *viz. March* 27, proved ſo et a Day, that almoſt five Pound of Rain fell through my Tun-l, a large Quantity for the Compaſs of twelve Inches Diameter fourteen or fifteen Hours Time. The Winds and Clouds were l the while calm and ſtill, and frequently changing from Point Point, near round the whole Compaſs; and the Rain that fell, ll thick in ſmall Drops. Which makes me think, that the warm ggy Vapours, raiſed in great Plenty the Day or two before, as ſoon as ey were mounted aloft, met with ſudden extreme Cold of the middle egion, and were thereby haſtily condenſed, and the Air being at the me Time very light (the Barometer being then very low) they ſpeedily mbled down in ſmall and thick Drops of Rain.

And this I take to be the very Caſe of the Vernal and Autumnal ains, that in Spring, when the Earth and Waters are looſed from e Brumal Conſtipations, the Vapours ariſe in great Plenty. So alſo Autumn, when the Heats that diſſipated them in Summer, and alſo armed the ſuperior Regions, are abated, the Vapours raiſed then in reat Plenty are ſoon condenſed by the Cold of the ſuperior Regions, nd ſo are forced down in more plentiful Rains, than at other Seaſons, hen either the Vapours are fewer, or Cold of the ſuperior Regions ſs.

For a farther Illuſtration of this, let us caſt an Eye upon *June* laſt, Month as unſeaſonably Wet, as 'twas unuſually Cold. The Cold ereof I have already taken notice of; and the wet Weather accompanying it was ſo unſeaſonable to us in *South Britain*, that altho' we ad great and welcome Crops of Hay after a great Scarcity the preeding Year, yet we had ſcarcely any good Weather to make it in. o Dr. *Scheuchzer* ſaith it was with them in *Switzerland*, in his Remarks n that Month: *This Month, as appears from meaſuring the Rain, was ore than ordinary wet, to the Injury both of Men and Vegetables. Much Iay was rotted, the Corn alſo that was not yet cut grew too luxuriant. he Vines and their Bloſſoms received much Damage from the continual ains; their tender Buds fell off, their Leaves were canker'd, and there ppear'd but ſmall Hopes from the approaching Autumn,* &c.

Having conſider'd the Uſe of Cold to the Production of Rain, I all remark one Thing concerning the *Alps*; and that is, I cannot but ink that thoſe, and all ſuch like high Mountains, and the Snows they re cover'd with, are of great Uſe to the neighbouring, and more di-ant Countries, in generating their Rain, and performing other great

Offices of Nature. From ſome Obſervations I have made in comparing Dr. *Scheuchzer*'s and my own larger Tables, having ſo frequently obſerved the Riſing and Fallings of the Barometer, ſome of the moſt conſiderable Variations of the Wind, the moſt remarkable Alterations of Heat and Cold, and of Wet and Dry; I have ſo often obſerved many of theſe to precede in one Place what hath followed in another, that I am apt to think that even *England* may ſometimes partake of the Effects of the *Alpine Mountains* upon the Air and Vapours. It is certain that their very cold Weather in *December* laſt, and the Relaxation thereof preceded ours: Which makes me inclin'd to think it might probably be derived from them to us. All the former part of that Month, eſpecially from about the 8*th* Day till the 24*th*, was here mild and open. But on *Chriſtmas* Day it began to be colder, and the following Days to freeze harder and harder; inſomuch that on *December* 30, my Thermometer was a great deal lower than ever I had ſeen it before. And two Perſons in *London* told me, that the Spirits in their Thermometers fell ſeveral Degrees lower this laſt Winter, than they had done in the ſelf-ſame Thermometers during all the long and remarkable Froſt in the Year 1683. Whether at *Zurich* the Cold was more exceſſive than it uſed to be in other Years, Dr. *Scheuchzer* doth not ſay; but he noteth the Air to have been exceſſively cold, and his Thermometrical Obſervations ſhew it to have been ſo ſome time before, in, and after *Chriſtmas*. And Dr. *Newton*, in a Letter to me from *Florence*, ſays, "The Cold was there ſo great, that for twenty "Years paſt they had not been ſenſible of greater; it wanting on "*Twelfth-day* but half a Degree of the Extremity". Their *Twelfth-day*,, I reckon, fell on *December* 26, *O. S.* and conſequently their ſo eminenly Freezing Day preceded ours about four Days.

And as their Cold, ſo by Dr. *Scheuchzer*'s Obſervations, I find the Relaxation thereof preceded ours a ſhort Time. For about the latter End of *December*, the Weather appears to have been milder, at leaſt leſs intenſely cold with them. And ſo was ours at the Beginning of *January*, about as many Days after theirs, as their Cold preceded ours.

Thus I have given one eminent Inſtance of what I found leſſer Examples frequently, as I run over Dr. *Scheuchzer*'s laſt Year's Obſervations. But whether there may be any farther Reaſons for any ſuch Concluſions about the Influences of the *Alpine* Eminences and Colds upon far diſtant Places, future Obſervations will determine. But as to their Influences nearer home, Dr. *Scheuchzer* ſaith, *The* Alps *are not only the fruitful Mother of Rivers and Clouds, but alſo of Snow and Rain It is very credible, that ſuch Places as are near the Sea and the* Alps, *abound more with Rain than Places which are more remote.*

To theſe Remarks I might add Dr. *Scheuchzer's* Obſervations of the Occurrences in each Month, of what was curious as to Meteors, the State of Health and Diſeaſes, *&c.* Alſo the Increaſe and Decreaſe of their *Zurich* River, the *Limat*, which (like other Rivers that have their Source in the *Alps*) he puts beyond all Doubt (in my Opinion) to receive greater Increments from the melting of the *Alpine* Snows, than from all the Wet proceeding from their Rains. But for them, I refer to his Obſervations at large.

From Dr. *Tilli's* Table of Rain, compar'd with the other Tables, it appears, that although, in the Year before, *June* and other Summer Months were dry, yet laſt *June* was a wet Month at *Piſa*, as well as *Zurich* and *Upminſter*; and ſo likewiſe was it about the Autumnal Equinox: And for the ſame Reaſons I imagine, which I have already mentioned.

As to the Exceſs of the *Piſa* Rain above that of other Places, he attributeth it to the ſame Cauſe, that I did that of *Lancaſhire*, namely, *the Height of the Hills, and the Blowing of the Winds for a long Time from ſome one Quarter.* His Obſervation is this, *I eaſily allow, that our Rain always or for the moſt part exceeds yours; for the Reaſon you have obſerved. And eſpecially if the rough* Corſican *Mountains, at the Time of Autumn, are covered early with Snow. Then the Southerly Winds and Showers prevail for a long Time. But it plainly appears that the North Winds blow more frequently about the Hills of* Florence *than the City of* Piſa. *For this City is ſurrounded with Hills on the North-ſide, and is diſtant about five Miles from the Sea at an equal Interval.*

The ſame Account of the Situation of *Piſa*, and the great Quantity of Rain falling there, I remember I had ſome Time ſince from a very ingenious Member of this Society, Mr. *Aſton*, who hath been there.

A Table ſhewing the Heights of the Mercury in the Barometer *in* Engliſh *Inches and Centeſimals of an Inch, both at* Zurich *in* Switzerland, *and at* Upminſter *in* South Britain, *together with the Differences of thoſe Heights, for the Year* 1708.

D. of M.	January. Zurich *in* Engl. *Inches.*	January. Upm. *in* Engl. *Inches.*	January. *Dif. in* Engl. *Inches.*	February. Zurich *in* Engl. *Inches.*	February. Upm. *in* Engl. *Inches.*	February. *Dif. in* Engl. *Inches.*	March. Zurich *in* Engl. *Inches.*	March. Upm. *in* Engl. *Inches.*	March. *Dif. in* Engl. *Inches.*
1	28 1	29 4	1 3	28	29 59	1 59	27 90	29 22	1 32
2				8	52	1 44	28	23	1 23
3	17	14	97	17	53	1 36	27 85	42	1 57
4	26	43	1 17	17	39	1 22	82	64	1 83
5	17	42	1 25	75	37	1 12	28	73	1 73
6	1	28	1 27	17	44	1 27	12	44	1 32
7	17	43	1 26	12	35	1 23	6	73	1 67
8	27 99	5	1 6	8	40	1 32	27 81	30 12	2 31
9	64	28 78	1 14	40	67	1 27	81	29 46	1 65
10	46	50	1 4	15	87	1 72	85	18	1 33
11	46	97	1 51	14	30 2	1 88	75	30	1 55
12	99	29 38	1 39	27 90	2	2 12	81	50	1 69
13	73	23	1 50	83	29 67	1 84	85	59	1 74
14	73	11	1 38	28	49	1 49	85	45	1 60
15	27 99	28 99	1	27 82	45	1 63	28 6	37	1 31
16				84	47	1 63	13	47	1 34
17	28 17	29 19	1 2	81	32	1 51	8	52	1 44
18	8	28 89	81	27 95	33	1 38	27 90	33	1 43
19	27 90	29 3	1 13	81	36	1 55	28 6	21	1 15
20	90	15	1 25	28	25	1 25			
21	81	28 80	99	17	8	91	27 85	34	1 49
22	73	95	1 22	38	41	1 3	72	8	1 36
23	99	29 12	1 13	35	48	1 13	72	13	1 41
24	90	20	1 30	17	47	1 30	85	6	1 21
25							81	34	1 53
26				20	25	1 5	75	29	1 54
27	81	57	1 66	15	22	1 7	85	16	1 31
28	81	95	2 14	27 95	28 99	1 4	28 4	38	1 34
29				85	94	1 9	27 90	37	1 47
30							95	6	1 11
31	28 08	76	1 68				28	14	1 14

	April.			May.			June.		
D. *of* M.	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*
1	28	28 97	0 97	28 0	29 53	1 53	27 95	29 65	1 70
2	27 95	94	0 99	6	69	1 63	28 6	55	1 49
3	90	29 28	1 38				27 81	86	2 5
4	81	53	1 72	8	50	1 42	83	30 7	2 24
5	90	45	1 55	0	44	1 44	35	29 96	2 61
6	85	65	1 80	8	41	1 33	90	69	1 79
7	90	65	1 75	6	36	1 30	28 8	52	1 44
8	28	50	1 50				27 90	50	1 60
9	00	60	1 60	26	62	1 36	90	56	1 66
10	27 64	62	1 98	12	63	1 51	28 0	56	1 56
11	75	77	2 2	0	46	1 46	27 90	58	1 68
12	72	62	1 90	27 90	66	1 76	28 6	59	1 53
13	90	80	1 90	81	79	1 98	27 81	36	1 55
14	28	91	1 91	75	83	2 8	85	49	1 64
15	6	89	1 83	72	68	1 96	90	60	1 70
16	8	88	1 80	54	66	2 12	85	47	1 62
17	27 95	93	1 98				28 3	44	1 41
18	95	85	1 90	64	44	1 80	27 81	40	1 59
19	28	89	1 89	72	58	1 86	81	47	1 66
20	6	88	1 82	90	74	1 84	85	73	1 88
21	6			28 0	81	1 81			
22	8	30	1 92	0	59	1 59	90	70	1 80
23	00	29 80	1 80	27 95	54	1 59	97	70	1 73
24				28 8	67	1 59	85	43	1 58
25	8	80	1 72	17	80	1 63	96	45	1 49
26	12	85	1 73	15	86	1 71			
27				27 85	84	1 99	72	81	2 9
28	6	76	1 70	28 8	81	1 73	73	99	2 26
29				0	87	1 87	72	98	2 26
30	00	37	1 37	0	84	1 84	75	80	2 5
31				27 90	78	1 88			

	July.			August.			September.		
D. of M.	Zurich in Engl. *Inches.*	Upm. in Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich in Engl. *Inches.*	Upm. in Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich in Engl. *Inches.*	Upm. in Engl. *Inches.*	*Dif. in* Engl. *Inches.*
1	28	29 72	1 72	27 85	30 2	2 17	28 16	29 58	1 52
2	27 95	92	1 97	81	29 84	2 3	00	54	1 54
3	97	89	1 92	85	70	1 85	17	50	1 33
4	95	80	1 85	28 6	72	1 56	8	48	1 40
5	28	67	1 67	10	67	1 67	27 72	61	1 89
6	27 75	69	1 94	8	56	1 48			
7	81	72	1 91	0	57	1 57	72	45	1 73
8	28	69	1 69	27 81	93	2 12	72	49	1 77
9	8	68	1 60	85	98	2 13			
10	12	80	1 68	90	62	1 72	81	45	1 64
11	0	84	1 84	95	66	1 71			
12	27 81	90	2 9	28 8	89	1 81	64	67	2 3
13	93	83	1 90	0	93	1 93	46	48	2 2
14	28 6	68	1 62	27 85	93	2 8	72	43	1 71
15				75	84	2 9	85	28 65	0 80
16				72	80	2 8			
17	27 95	63	1 68	73	55	1 82	72	29 30	1 58
18	90	77	1 87	72	19	1 47	69	67	1 98
19	28	76	1 76	90	61	1 71			
20	27 72	84	2 12	95	81	1 86	72	88	2 16
21	28	66	1 66	72	93	2 21	75	86	2 11
22	6	50	1 44	81	77	1 96	75	85	2 10
23	17	56	1 39	90	93	2 3	75	96	2 21
24	8	84	1 76	95	53	1 58	81	30 20	2 39
25	6	73	1 67	28 00	51	1 51	56	17	2 61
26				00	51	1 51	50	12	2 6
27	27 95	82	1 87	27 95	52	1 57	64	89	2 25
28	85	54	1 69	85	63	1 78	81	94	2 1
29	95	66	1 71	28	51	1 51			
30	85	61	1 76	27 85	62	1 77	72	73	2
31	81	96	2 15	28 6	56	1 50			

October.

D. *of* M.	October.			November.			December.		
	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*	Zurich *in* Engl. *Inches.*	Upm. *in* Engl. *Inches.*	*Dif. in* Engl. *Inches.*
1	27 72	29 92	2 20	28 22	30 21	1 99	28 26	29 36	1 10
2	69	93	2 24	24	18	1 94	30	45	1 15
3							22	50	0 83
4							27 99	28 96	0 97
5	72	73	2 1	15	6	1 91	73	92	1 19
6	85	30 5	2 20	08	12	2 4	77	29 11	1 34
7				17	29 86	1 69	85	11	1 26
8	81	29 94	2 13				99	15	1 16
9				22	30 8	1 86	28 15	24	1 9
10	72	86	2 14	17	10	1 93	15	24	1 9
11	64	86	2 22	22	29 78	1 56	08	28	1 20
12	72	30 6	2 34				27 99	40	1 41
13				22	30 10	1 88	90	59	1 69
14	90	29 41	1 51	17	00	1 83	73	83	2 10
15									
16				22	15	1 93			
17	87	79	1 92	26			75	74	1 99
18	28 6	59	1 53				90	77	1 77
19	00	49	1 49	22	29 88	1 66	95	52	1 57
20	27 72	70	1 98				99	60	1 61
21	72	30 00	2 28	22	50	1 28	28 6	61	1 55
22	90	2	2 12				6	50	1 44
23	95	29 76	1 81	27 77	27	1 50	27 99	77	1 78
24	95	74	1 79	90	60	1 70	28 17	28	1 11
25	64	89	2 25	28 17	84	1 67	26	36	1 10
26	85	80	1 95				17	30 14	1 97
27	81	67	1 80				22	28	2 6
28	81	63	1 74						
29	28 00	64	1 64				17	29 83	1 66
30	27 90	80	1 90	26	45	1 19	15	80	1 65
31	28 00	73	1 73				17	49	1 32

A Table of the Rain at Piſa *in* Italy, *both in* Tuſcan *and* Engliſh *Troy Weight, which fell through a Tunnel of half a Brace ſquare, from* May *till the End of* December 1707: *As alſo the Quantity of Rain at* Upminſter *in* Eſſex *at the ſame Time, which fell through a round Tunnel of* 12 *Inches Diameter, in Pounds Troy, and Centeſimals of a Pound.*

	May.			June.			July.		
D. of M.	Piſa *Rain in* Tuſcan *Weight.*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.	*Rain at* Piſa *in* Tuſcan *Weight.*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.	Piſa *Rain in* Tuſcan *Weight.*	Piſa *Rain reduced to* Eng. *W.*	*Rain at* Upminſter.
	l. oz	*l. dec.*	*l. dec.*	*l. oz.*	*l. dec.*	*l. dec.*	*l. oz.*	*l. dec.*	*l. dec.*
1						0 17			0 1
2						2 90			
3						0 05			0 92
4									0 40
5									0 25
6						0 55	2 0	1 84	
7									
8				5 7	5 12				
9									
10						0 06			
11						0 2			0 60
12									0 12
13									0 3
14									
15						0 29			
16									0 17
17									0 16
18							0 3	0 23	
19									
20									
21									
22	0 9	0 69	2 70						0 94
23			1 26						0 65
24			0 17			0 85			
25						0 42			
26									
27						0 33			0 92
28						0 23			0 20
29			0 56						
30			0 56			0 81			
31	*Tot: wt*	0 69	5 25		5 12	6 68		2 7	6 37
Dep. in Inch		0 12	1 05		0 88	1 34		0 25	1 27

	August.			September.			October.		
D. of M.	Piſa Rain in Tuſcan Weight.	Piſa Rain reduced to Eng. W.	Rain at Upminſter.	Rain at Piſa in Tuſcan Weight.	Piſa Rain reduced to Eng. W.	Rain at Upminſter.	Rain at Piſa in Tuſcan Weight.	Piſa Rain reduced to Eng. W.	Rain at Upminſter.
	l. oz.	l. dec.	l. dec.	l. oz.	l. dec.	l. dec.	l. oz.	l. dec.	l. dec.
1									
2	1 1	1 0	1 . 90						2 54
3							4 8	3 28	
4			0 76						
5			0 09						0 69
6			3 34			0 51			
7			0 16				7 7	6 96	
8			0 45			0 02			
9			0 81			0 04			
10						1 40	1 9	1 61	
11				0 50	0 38	0 70			
12							2 3	2 06	
13			0 10	0 4	0 31	0 51			
14			0 07	2 11	2 68	0 06			
15							3 10	3 52	
16							1 8	1 63	
17			1 68						
18						0 10			
19	32 5	29 75	0 10			0 . 87			
20	1 8	1 53	1 02	3 8	3 36				
21				7 9	7 11	1 65			1 62
22				10 0	9 18				
23				3 2	2 91				0 80
24	1 4	1 23		6 10	6 27	2 73			0 26
25						0 . 85			
26						0 46			
27						2 76			
28				5 10	5 35				0 71
29			0 31			1 84			
30			0 09						
31	Total.	33 51	88		37 55	14 50		19 66	6 62
Dep. in Inch		5 · 76	2 176		6 45	2 90		3 43	1 324

D. of M.	November.						December.					
	Rain at Piſa *in* Tuſcan *Weight.*		Piſa *Rain reduced to* Eng. *W.*		*Rain at* Upminſter.		Piſa *Rain in* Tuſcan *Weight.*		Piſa *Rain reduced to* Eng. *W.*		*Rain at* Upminſter.	
	l.	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1												
2							2	8	2	45	0	44
3					0	33					0	65
4												
5												
6			1	84							0	63
7											0	25
8							5	4	4	89		
9	9	4	8	57							0	84
10							2	10	2	60		
11												
12							2	8	2	45	1	67
13												
14					0	53						
15											1	24
16							3	10	3	52	0	96
17					0	32						
18												
19	3	9	3	44								
20							5	6	5	05	0	82
21					0	86					1	38
22											0	22
23	9	5	8	64							0	25
24	0	6	0	46	3	08						
25	2	4	2	14							0	16
26					0	28	3	2	2	91		
27	1	5	1	30			7	3	6	65	0	62
28											1	98
29					0	50	7	5	6	80		
30											0	03
31	*Tot.wt*		24	55	5	90			37	32	12	14
Dep.in Inch			4	22	1	18			6	39	2	428

A Table of the Rain at Zurich *in* Switzerland, *at* Piſa, *and* Upminſter, *in the Year* 1708. *All reduced to the Depth in* Engliſh *Inches, and Centeſimals of an Inch.*

	January.							February.						
D. of M.	*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.		*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.	
	Inches.	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*Inches.*	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1		5	8	5	20									
2	1							2 ½	3	3	2	98		
3														
4		7	2	6	58	0	97	1 ¼						
5	1					0	29	¼	0	10	0	76		
6						0	7	2					0	2
7														
8								2						
9		6	3	5	74	0	53		2	4	2	14		
10						2	48		1	8	1	53		
11						1	26							
12								2 ½	0	9	0	69		
13						1	91							
14		3	4	3	6	1	88							
15	4					0	4	½					0	18
16						0	92							
17		5	6	5	5			1 ¼						
18		2	9	2	52	1	26							
19								4 ¼						
20	1 ½							⅛	2	1	1	90	0	54
21	1												0	51
22	4					0	91							
23	2								7	2	6	58	0	64
24	2	3	6	3	21									
25	1 ½					1	7						0	19
26						0	80							
27		4	1	3	75									
28										9	2	52		
29	½							½					0	22
30														
31		2	5	2	22									
Tot	18 ½			37	33	14	39	18 ⅜			19	10	2	30
Dep	1 64			6	41	2	88	1 65			3	28	0	46

D. of M.	March.								April.							
	Rain at Zurich.		*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.		*Rain at* Zurich.		*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.	
	Inches.		*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*Lines.*		*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1	2	¾							9	¾					1	16
2											2	10	1	68	0	16
3									7	¾	2	4	2	14		
4											0	9	0	69		
5															1	54
6							1	27								
7									1							
8									3							
9															0	16
10							0	38	1	¼					0	24
11							0	37		¼						
12	3	½													0	85
13			8	1	7	40										
14							0	37		⅓						
15		½														
16									4	¾						
17									5	½	0	10	0	76		
18			6	3	5	74			3	¼						
19	2	¾					0	25			2	2	1	99		
20							0	8	5							
21							0	20								
22							1	37								
23	2	⅙					1	06	6							
24							1	37		½						
25							1	43	3	¼						
26		¼								⅓						
27							1	29								
28							0	15								
29							0	54							0	65
30	1	½													0	01
31	3	½	2	6	2	29										
Tot	17	⅙			15	43	10	13	52	¼			7	26	4	77
Dep	1	51			2	65	2	3	4	69			1	25	0	96

	May							June.						
D. *of M.*	*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.		*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.	
	Lines.	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*Lines.*	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1								1 ½						
2									4	1	3	75	0	66
3						1	09	21 ¾	2	2	1	99		
4		5	1	4	66									
5						0	27	2 ½	3	4	3	06		
6		4	4	3	98				2	8	2	45		
7		3	10	3	52	3	28						0	60
8						0	82	1 ¾	3	3	2	98	0	20
9						0	11						0	90
10									0	9	0	69	0	11
11														
12	1 ¼												1	66
13						0	32	½					0	15
14	⅓								2	1	2	68	0	76
15	2 ⅓					1	11	3 ¾	0	10	0	76		
16						0	82							
17	½					0	01						0	01
18						0	96		11	1	10	17	0	93
19	5 ¼												0	04
20	3 ¼							19						
21						0	53						2	66
22						0	79	1						
23													1	23
24								6 ¼					0	80
25		3	4	3	06								0	44
26								1 ¼					0	38
27	2 ¼													
28								½						
29	1													
30		2	10	2	06			6 ¾					0	08
31	4 ½	1	8	1	53									
Tot	21 ⅓			19	35	10	11	66 ½			28	53	11	61
Dup	1 91			3	33	2	02	5 91			4	90	2	32

	July.					August.						
D. of M.	*Rain at* Zurich.			*Rain at* Upmin.		*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.	
	Lines.			*l.*	*dec.*	*Lines.*	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1	1			0	06							
2												
3	2 ½											
4				0	03							
5												
6	25 ½											
7											3	38
8				0	93							
9				0	49							
10				0	59							
11				0	47						0	07
12				0	01							
13				0	11							
14							10	1	9	25		
15				1	00		1	8	1	53		
16				0	16							
17							2	8	2	45	1	05
18	3					3 ¼					0	56
19												
20	2 ⅔											
21				0	01							
22												
23						27 ¾						
24				0	01						0	15
25				0	41	1 ¼					0	76
26	¾											
27											0	31
28	¾			1	20							
29	⅙					2 ½					1	32
30	3			0	04	¼						
31											7	10
Tot	39 ⅓			5	52	35 ⅓			13	23	14	70
Dep	3 50			1	11	3 15			2	27	2	94

D. of M.	September.							October.						
	Rain at Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.		*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.	
	Lines.	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*Lines.*	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*
1		1	2	1	07				5	1	4	67		
2													0	03
3		10	0	9	18	0	74							
4						0	06							
5													0	08
6						0	64							
7	2	12	2	11	17									
8	7 ¾					0	40							
9	4 ¼								4	4	3	98		
10						0	05							
11						0	01	4 ¼	14	5	13	13		
12						1	41						0	06
13													0	37
14	5 ¾					1	24						0	16
15	2 ¾	2	8	2	45	1	10		2	3	2	06		
16														
17														
18	7 ¾					0	29		2	6	2	29	0	31
19									1	9	1	61		
20														
21		10	4	9	48			13 ½						
22														
23						0	27						0	02
24		9	4	8	57									
25														
26								6 ¾	3	7	3	29		
27	3 ¾													
28													0	06
29						0	99							
30						0	08							
31								2 ¾					0	05
Tot	34			41	92	7	28	27 ½			31	03	1	14
Dep	3 02			7	21	1	46	2 44			5	33	0	23

	November.							December.				
D. of M.	*Rain at* Zurich.	*Rain at* Piſa.		Piſa *Ra. reduced.*		*Rain at* Upmin.		*Rain at* Zurich.			*Rain at* Upmin.	
	Lines.	*l.*	*oz.*	*l.*	*dec.*	*l.*	*dec.*	*Lines.*			*l.*	*dec.*
1		3	3	2	98						0	10
2												
3											0	61
4						0	92				0	08
5								17 ½			0	27
6												
7												
8											0	30
9		2	0	1	84						0	66
10												
11						2	22					
12	¾	3	6	3	21	2	26					
13								8				
14												
15												
16												
17											0	54
18												
19											1	84
20												
21											1	22
22												
23	6 ¾										4	00
24											0	22
25												
26												
27												
28												
29												
30						0	90	½				
31								3 ½				
Tot	7			8	03	4	30	29 ½			9	84
Dep	0 62			0	13	0	86	2 62			1	97

A Proſpect of all the Rain *in the foregoing Tables, in every Month, Half Year, and the whole Year, from* June 1. *N. S. or* May 21. *O. S.* 1707. *to the End of the Year* 1708.

	Depth of the Piſa *Rain.*	*Depth of the* Upm. *Rain.*	*Depth of the* Zurich *Rain.*
	Engl. *Inches.*	Engl. *Inches.*	Engl. *Inches.*
May.	0 12	1 05	
June.	0 88	1 34	
July.	0 36	1 27	
Auguſt.	5 76	2 18	
September.	6 45	2 90	
October.	3 43	1 33	
November.	4 22	1 18	
The Half Year's Rain.	21 22	11 25	
December.	6 39	2 43	
Anno 1708.			
January.	6 41	2 88	1 64
February.	3 28	0 46	1 65
March.	2 65	2 03	1 51
April.	1 25	0 96	4 69
May.	3 33	2 02	1 91
The Half Year's Rain.	23 31	10 78	
Depth of the whole Year's Rain.	44 53	22 03	
June.	4 90	2 32	5 91
The Half Year's Rain.		10 67	17 31
July.		1 11	3 50
Auguſt.	2 27	2 94	3 15
September.	7 21	1 46	3 02
October.	5 33	0 23	2 44
November.	0 13	0 86	0 62
December.		1 97	2 62
The Half Year's Rain.	19 84	8 57	15 35
The whole Year's Rain.		19 24	32 66

An Account of the Rain *at* Upminſter *for* 18 *Years, by Mr.* W. Derham. n. 341. p. 130.

XI. The laſt Year (1714) having been ſo remarkably dry, that the Ponds hereabouts are for the moſt part dry, and the Springs generally either very low or quite failing, I made an Extract (out of my Regiſters of the Weather, *&c.*) of the *Quantity of Rain* which fell at *Upminſter* the laſt 18 Years. The Particulars of which, every Year, may be ſeen in the Table. In one Column of which, the Weight of the Rain in Pounds *Troy*, and Centeſimals of Pounds, may be ſeen; in the other, the Depth of it in Inches and Centeſimals of Inches, or what Height it would have been, had it not been imbib'd by the Earth, or leſſen'd by Exhalations, but been ſuffer'd to have ſtagnated on the Ground.

A Table of Rain which fell at *Upminſter*, from the Year 1697, to the Year 1714.

Year.	Weight.		Depth.	
	l.	Cent.	Inch.	Cent.
1697	77	60	15	52
1698	122	32	24	46
1699	75	54	15	11
1700	95	13	19	03
1701	93	45	18	69
1702	101	89	20	38
1703	119	94	23	99
1704	79	02	15	81
1705	84	62	16	93
1706	121	43	24	29
1707	81	55	16	31
1708	96	09	19	22
1709	132	82	26	56
1710	91	84	18	37
1711	118	02	23	60
1712	118	78	23	76
1713	115	80	23	16
1714	55	95	11	19

Remarks on the Dry Year 1704.

Among the *Dry Years*, 1704 was complain'd of for one; which I remember the News-Papers reported to have been ſo conſiderable at *Venice*, that they were forc'd to fetch their Water in Barks five Leagues off, as far as the *Brenta*; ſo that publick Prayers were put up for Rain. Yet we may obſerve, that ſeveral other Years were drier that that with us at *Upminſter*. But among them all, none comparable to the laſt Year 1714. In which the whole Quantity of Rain was no more than 55 *l.* 95 Hundredths, or 11 Inches 19 Hundredths; whereas the leaſt Quantity of any of the preceding 18 Years, exceeded 15 Inches in Depth.

What Effects this Drought hath had in the Bodies of Animals, I leave others to judge. It is well known how contagious and fatal a Diſtemper hath raged among, not only our own black Cattle, but in many other Parts of *Europe.* And I obſerved the *Itch* was Epidemical among the poorer Sort, at the Beginning of the Year; that the *Meaſles* were very common ſome Parts of the Year; and that *Pleuriſies* and *Malignant Fevers* infeſted a great many, eſpecially in the Summer Months. But how far theſe Diſtempers might be owing to the dry Seaſon, I leave to the Phyſicians.

To compare with theſe, we have collected out of the *Memoirs* of the *Royal Academy* of *Sciences*, the Quantity of *Rain* and diſſolved *Snow* which has fallen at the *Obſervatory* at *Paris* for 23 Years together; according to the accurate Obſervation of M. *De la Hire*, and have reduced the *French* Meaſure to our own. But it is to be obſerved, that the Diverſity of *Stile* makes the Years not exactly the ſame, though, as to this Matter, the Difference may ſeem very inconſiderable.

The Rain at Paris *for* 23 *Years.*

	French		*Engliſh.*	
Anno	Inch	Lin.	Inch	Cent.
1689	18	11½	20	23
1690	23	3⅔	24	87
1691	14	5¼	15	40
1692	22	7½	24	14
1693	22	8	24	18
1694	19	9	21	07
1695	19	7⅔	20	96
1696	19	5½	20	76
1697	20	3	21	68
1698	21	9	23	20
1699	18	8⅛	19	93
1700	20	0⅜	21	38
1701	21	4⅛	22	78
1702	16	4	17	42
1703	17	4⅛	18	51
1704	19	10½	21	20
1705	13	10⅔	14	82
1706	15	3½	16	32
1707	17	11	19	11
1708	18	3½	19	51
1709	21	9⅛	23	21
1710	15	8¼	17	10
1711	25	2	26	84

A Storm of Rain at Denbigh *in* Wales, *by* —— n. 308. p. 2348.

XIII. Upon *Tueſday*, the 16*th* Day of *July* 1706, about Eight of the Clock in the Morning, it began to rain in and about *Denbigh*, which continued inceſſantly for 30 Hours, but not very violently, till about Three or Four a-Clock in the Morning upon *Wedneſday*, when it rain'd ſomewhat faſter, attended with a terrible Noiſe (like Thunder) with ſome Flaſhes of Lightning, and a boiſterous Wind. About Break of Day the Rain and Wind began to abate of their Violence, which leſſen'd gradually every Hour, till about One or Two a-Clock in the Afternoon, and then it perfectly ceaſed, and the Air became clear and ſomewhat calm.

Upon *Tueſday* the Wind blew South Weſt; but on *Wedneſday* it was come to the North Weſt.

The Effects of this great Storm were diſmal, for it occaſion'd the overflowing of all the Rivers in *Denbighſhire*, *Flintſhire*, and *Merionethſhire*, &c. which ſpoil'd a great deal of Corn, and took off all the Hay that was mowed, near the Banks of the Rivers, which was carried by the Stream in ſuch vaſt Quantities down to the Bridges, that it choak'd the Arches and Inlets, inſomuch that it broke down above a Dozen great Bridges. Great Oaks, and other large Trees were unrooted and ſwept away, with ſeveral Quickſet Hedges; and ſome Quillets by the Side of the River *Elwy*, ſo covered with Stones and Gravel, that the Owners can't well tell whereabouts their Hedges and Landmarks ſtood; and the ſame River has alter'd its Courſe in ſome Places, ſo as to rob the Landlords on one Side of ſome Acres, and beſtowed as much on the oppoſite Side. Two or three Rivulets, that convey'd Water to ſome Mills, have been ſo choak'd up with Stones and Gravel, that the Owners don't think the Profit will countervail the great Charge of clearing them.

It is affirmed by many, that the great Floods were not ſo much the Effects of the Rain, as the breaking out of an infinite Number of Springs, in ſuch Places, as they were never known to flow from before. In the Town of *Denbigh* a great many broke out in the Houſes and Stables, eſpecially in that Part which lies next the Caſtle on the North Side of it, ſome of which broke out with a great deal of Violence, and in ſuch a Quantity, that it is affirmed by ſeveral Men of the Town, that three of theſe new Springs, which flowed out of the Stables of three Inns, were ſufficient to turn any Corn Mill.

At a ſmall Diſtance, Northward of *Denbigh*, lies *Park-Snodiog*, a Rocky Hill, out of which broke out a great many Springs, which flowed ſo plentifully for nine or ten Days, that the Cattle water'd in them for that Time; whereas before and after, the People were forc'd to water them all Summer long at a Well in the Highway, at ſome Diſtance from this *Park-Snodiog*. There are ſeveral deep Holes and Trenches cut in the Highways adjoining to the River *Elwy*, &c. ſome ſo very large, as to hide three or four Horſes, which is not attributed ſo much to the overflowing of the River, as to the breaking out of Springs in thoſe very Places.

In *Comb* Mountain there is a Pit of a circular Form, which in the Summer time uſed to have little or no Water in it, and in Winter, as much Water as would ſwell the Surface to about fourteen or ſixteen Yards croſs over: But now in the midſt of Summer it roſe up at leaſt a Yard and a half higher than it was ever known to do in the wetteſt Winters; and overflowing its Banks, it fell down the Hill with ſuch Violence, as to penetrate into the very Body of a Rocky Road, and dug Pits in it, that will bury the biggeſt Horſes; and the Road, which was a common Highway, is now become irreparable.

XIV. 1.] In the Month of *March* 1701, in the Forenoon, between the Hours of 10 and 11, I obſerved a remarkable *Water-Spout* in the *Downs*. It bore N by E off our Ship, about two Leagues diſtance by Eſtimation; the Wind at E N E. a Top-ſail Gale, and very cold. The Horizon was entirely open and ſerene, except the Northern Parts thereof from N N W to N E by E. or thereabouts. The higheſt Part of the Cloud appear'd to make an Angle of 45 Deg. of Elevation. About one half of the Cloud, (*viz.* the upper) was very white, and the other extreamly black. The Spout itſelf, (which hung from the lower Part of the whitiſh Cloud) hovered up and down for about 20 Minutes, and during two or three Minutes of the Time, that Part of the Sea exactly under the Spout, did ſparkle up Water to a conſiderable Height. The ſparkling run along to the Leeward, (the Cone of the Spout moving that Way, and making, it ſeems, a Diſcharge, tho' not viſible to us in its Fall) and continued running along for ſix Ships length. Afterwards the Body of the Spout did quickly contract itſelf, and then diſappear'd. About two Hours afterwards the Heavens were intirely overcaſt, and during that Afternoon there fell abundance of Hail, and both Wind and Cold increaſed. I have ſeen ſeveral Water-ſpouts in the *Mediterranean* ſome Years ago, and thoſe uſually during the Time of a ſtark Calm and hot Summer Weather; but to ſee one in our Northern Climate at this Time of the Year, and during Weather both Cold and Windy, is, I think, a little unuſual.

A Water-Spout *obſerv'd in the* Downs, *by Mr.* P. Gordon, n. 270. p. 805.

2.] The 27th of *Auguſt* 1701. being upon the Coaſt of *Barbary*, to the Northward of the Town of *Bona*, upwards of 10 Leagues diſtance at Sea, about 7 a-Clock at Night, ſoon after Sun-ſetting, there appeared in the N E. (which was directly up the Gulf of *Lyons* from us) great and continued Flaſhes of Lightning one after another, with ſcarce any Intermiſſion, and this without Thunder continued till the next Morning; the Flaſhes of Lightning ſometimes repreſenting the ſudden Appearance of a Star, and at other times of a Flaming Sword, and again of a Silver Cord ſtretched along the Clouds, or as the irregular Crack of a Wall from Top to Bottom.

Spouts *in the* Mediterranean, *by Dr.* A. Stuart. n. 277. p. 1077.

About eight next Morning we had Thundring, with a Continuation of Lightning of the Kind and Appearance above-mentioned, all from the N E. or thereabouts.

About nine the ſame Morning, fell down from the Clouds (which look'd diſmally black, lowring, and, as it were, heavy with Rain) in the ſaid N E. quarter, three Water-ſpouts, that in the middle being the greateſt, ſeem'd as big as the Maſt of a Ship, and I judg'd it to be at leaſt a League and a half diſtant from us; ſo that in itſelf, no doubt, it was bigger than three Maſts. The other two were not by half ſo big. All of them black, as the Cloud from whence they fell; all of them ſmooth, without any Knot or Irregularity; only at firſt falling, ſome fell perpendicularly down, and ſome obliquely, and all of them ſmaller at the lower end than above, giving the Repreſentation of a Sword; ſometimes alſo one of 'em would bow itſelf, and again become ſtraight, and alſo ſometimes became ſmaller, and again increaſed its Bulk; ſometimes it would diſappear, and immediately fall down again; ſometimes it became extenuated to the Smallneſs of a Rope, and again became groſs as before.

There was always a great boiling and flying up of the Water of the Sea, as in a *Jette d'eau*, or Water-work; or this riſing of the Water had the Appearance of a ſmoaking Chimney in a calm Day. Some Yards above the Surface of the Sea the Water ſtood as a Column or Pillar, and then ſpread itſelf, and was diſſipated as Smoak: And the Sword-like Spout from the Clouds either came down to the very middle of this Pillar, and as it had been joined with it, as the greateſt, which fell perpendicularly down, ſtill did from beginning to end: Or elſe it pointed to this Column of Water, at ſome Diſtance, either in a perpendicular or oblique Line, as the other two leſſer.

There were three or four Spouts more, which appear'd at the ſame time in the ſame Quarter of the Heavens, but neither for Bulk or Duration like theſe three: Thoſe appear'd or diſappear'd ſeveral times, during the Continuance of theſe three.

It was hardly diſtinguiſhable whether the Sword-like Spout fell firſt down from the Cloud, or the Pillar of Water roſe firſt from the Sea, both appearing oppoſite to one another all of the ſudden, as in the twinkling of an Eye. Only I obſerved of one, that the Water boiled up from the Sea to a great Height, without the leaſt Appearance of a Spout pointing to it either perpendicularly or obliquely, and here the Water of the Sea never came together in the Form of a Pillar or a Column, but did fly up ſcatteredly, the Sea being in a boiling Rage round the Place. The Wind being then N E. the ſaid boiling advanced towards the S W. as a flitting or moving Buſh upon the Surface of the Sea, and at laſt ceaſed. This proves that the boiling or flying up of the Water of the Sea may begin before the Spout from the Cloud appears to us: And indeed if there be any ſmall Matter of Priority betwixt theſe two Appearances, the boiling or throwing up of the Sea-water has it: Which begins firſt to boil, and then frames it ſelf into a Pillar of Water, eſpecially on the lower Part thereof.

It was obſervable of all of them, but more perceptible of the great one; that towards the end it began to appear like a hollow Canal, only black in the Borders, but white in the Middle; and though at firſt it was altogether black and opaque, yet now one could very diſtinctly perceive the Sea-Water to fly up along the Middle of this Canal, as Smoak up a Chimney, and that with great Swiftneſs, and very perceptible Motion. And then ſoon after the Spout or Canal brake in the Middle, and diſappear'd by little and little: The boiling up, and the Pillar-like Form of the Sea-Water continuing ſtill the laſt, even for ſome conſiderable Time after the Spout diſappear'd, and perhaps till the Spout appear'd again, which it commonly did in the ſame Place as before, breaking and forming itſelf again ſeveral times in a quarter of an Hour, or half an Hour's Time.

The Middle one of the three, exceeded all the reſt in Bigneſs, Perpendicularity, Conſtancy of Form and Situation, as well as Duration; but at laſt vaniſhed.

I know not, if any has accounted for this *Phænomenon*, but I imagine it may be ſolv'd by Suction (improperly ſo call'd) or rather Pulſion, as in the Application of a Cupping-glaſs to the Fleſh, the Air being firſt voided by the kindled Flax.

It was farther obſervable, that the oblique Spouts pointed always from the Wind; that is, that the Wind being at N. E. the oblique Spouts always pointed to the S. W. tho' at the ſame Time and Moment there were others perpendicular, which remained ſtill ſo, notwithſtanding the Wind.

Alſo that ſuch as were curved had ſtill the Convex ſide from the Wind, and the Concave towards it; that is, the Wind being at N. E. the Concave was towards the N. E. and the Convex towards the S. W.

It rained a great deal during the Continuance of theſe Spouts, and after their total Diſappearance we had half an Hour's violent Gale of Wind from the N. E. with very little Rain, the Weather afterwards clear'd up.

The Explication of the Tables.

A The Spout of a black Colour, falling out of a black Cloud perpendicularly. Fig. 10.

B The Water of the Sea, riſing in the Form of a Pillar or Column in the Middle, and ſcatter'd round about the ſaid middle Column, in form of Smoak, or rather like the falling of a *Jette d'eau.* Theſe two meet one another directly, and the Column of Water from the Sea is commonly groſſer than the Spout from the Clouds.

A A curved Spout, joining with the riſing Water of the Sea at B. Fig. 11.

A Repreſents a black Spout, falling obliquely from the Clouds of the ſame Colour. Fig. 12.

B Repreſents the aſcending Column of the Sea-Water as in *Fig.* 10. with this Difference, that here the Spout and Column of Water meet not.

E and W in this Fig. ſignify Eaſt and Weſt. Fig. 13.

1 2 3

Fig. 13. 1 2 3 Repreſent the ſucceſſive Progreſſion of the boiling of the Sea from Eaſt to Weſt, or from N. E. to S. W. and that without any Appearance of a Spout from the Clouds, pointing to either of theſe Places.

Fig. 14. A Repreſents the big perpendicular Spout a little before its breaking, white in the Middle.

B The Column of Sea Water joining therewith.

2 2 2 2 The Water of the Sea, aſcending in the Form of Smoak up a Chimney, all along the Column at B to the Clouds.

Fig. 15. A The breaking of a perpendicular Spout, commonly beginning in the Middle at A.

B The Riſe of the Sea Water, which begins to fail, and the middle Column to diſappear.

Fig. 16. A An oblique Spout, which after reaching to the Sea in a curved Line, or obtuſe Angle, does ſoon after break at A, and diſappear.

B the Riſing of the Sea Water alſo beginning to ceaſe.

Fig. 17. A A perpendicular Spout beginning to fall.

B The beginning Aſcent of the Water of the Sea under it.

Fig. 18. A An oblique Spout beginning, or darting itſelf out of the Clouds.

B. The riſing or boiling of the Water, anſwering to it in an oblique Line.

These ſometimes reach down to the Sea or riſing Water, and ſometimes they do not reach thither, but continue a while, as here repreſented.

A Water-Spout at Hatfield *in* Yorkſhire, *by Mr.* Abr. de la Pryme. n. 281. p. 1248.

3.] On the 15th of *Aug.* 1687. about two in the Afternoon, appeared a *Spout* in the Air at *Hatfield* in *Yorkſhire*; it was about a Mile off coming directly to the Place where I was; I took my Proſpective Glaſſes to obſerve it as well as I could.

The Seaſon was very dry, the Weather extreme hot, and the Air very cloudy, the Wind aloft, and pretty ſtrong, and (which is remarkable) blowing out of ſeveral Quarters at the ſame Time, and filling the Air hereabouts with mighty thick and black Clouds, layer upon layer; the Wind thus blowing ſoon created a great *Vortex*, Gyration, and Whirling amongſt the Clouds; the Center of which every now and then dropt down in the Shape of a thick long black Pipe, commonly call'd a Spout; in which I could diſtinctly view a Motion like that of a Screw, continually drawing upwards, and ſcrewing up (as it were) whatever it touch'd. In its Progreſs it mov'd ſlowly over a Hedge-Row and Grove of young Trees, which it made to bend like Hazle Wands, in a circular Motion; then going forward to a great Barn, it twitch'd off in a Minute all the Thatch, and fill'd the whole Air therewith. Coming to a very great Oak Tree, it made it bend like the foregoing Trees, and broke one of the greateſt and ſtrongeſt Branches, that would not yield to its Fury, and twiſting it about, flung it a very conſiderable Diſtance off; then coming to the Place where I ſtood, within 300 Yards of me, I beheld this odd *Phænomenon*, and found that it proceeded from nothing but a Gyration of the Clouds by contrary Winds meeting in a Point or Center; and, where the greateſt Condenſation and Gravitation was, falling down into a Pipe or great Tube (ſomething like the *Cochlea Archimedis*) and that in its working or whirling Motion, either ſucks up Water, or deſtroys Ships, *&c.* having travell'd about a Quarter of a Mile farther, it diſſolv'd by the Prevalency of the Wind that came out of the Eaſt.

—*another, by the ſame,* n. 284. p. 1331.

4.] I have ſeen another Spout in the ſame Place, which very much confirms me in my Notion of the Origin and Nature of them. The Weather here in this Part of the Country, hath been exceeding wet and cool, inſomuch that it ſeem'd rather to be Spring than Midſummer; yet the 21ſt of *June* 1702 was pretty warm; on the Afternoon of which Day, about two of the Clock, no Wind ſtirring below; tho' it was ſomewhat great in the Air, the Clouds begun to be mightily agitated and driven together; whereupon they became very black, and were (moſt viſibly) hurried round, from whence proceeded a moſt audible whirling Noiſe, like that commonly heard in a Mill. After a while, a long Tube or Spout came down from the Center of the congregated Clouds, in which was a ſwift ſpiral Motion like that of a Screw, or the *Cochlea Archimedis*, when it is in Motion, by which ſpiral Nature and ſwift turning, Water aſcends up into the one as well as into the other. It travell'd ſlowly from Weſt to North Eaſt, broke down a great Oak Tree or two, frighted ſome out of the Fields, and made others lie down flat upon their Bellies, to ſave being whirl'd about and kill'd by it, as they ſaw many Jackdaws to be that were ſuddenly catch'd up, carried out of Sight, and then caſt a great way amongſt the Corn; at laſt it paſs'd over the Town of *Hatfield*, to the great Terror of the Inhabitants, filling the whole Air with the Thatch that it pluck'd off from ſome of the Houſes; then touching upon a Corner of the Church, it tore up ſeveral Sheets of Lead, and roll'd them ſtrangely together; ſoon after which, it diſſolved and vaniſhed without doing any further Miſchief.

By all the Obſervations that I could make of this, and the former, I found that had they been at Sea, and join'd to the Surface thereof, they would have carried a vaſt Quantity of Water up into the Clouds, and the Tubes would then have become much more ſtrong and opake than they were, and have continued much longer.

It is commonly ſaid that at Sea the Water collects and bubbles up a Foot or two high under theſe Spouts before that they be joined: But the Miſtake lies in the Pellucidity and Fineneſs of thoſe Pipes, which do moſt certainly touch the Surface of the Sea before that any conſiderable Motion be made in it, and that when the Pipe begins to fill with Water, it then becomes opaque and viſible.

As for the Reaſon of their diſſolving of themſelves after that they have drunk up a great Quantity of Water, I take it to be through the great Quantity of the Water that they have carried up, which muſt needs thicken the Clouds, and impede their Motion, and by that Means diſſolve the Pipes.

A Fall of Water from a Spout *in* Lancaſhire, *by Dr.* R. Richardſon. n. 363. p. 1097.

5.] We have frequent Accounts of Damage done at Sea by Spouts of Water, yet ſuch rarely happening at Land, induc'd me to take the following Relation of a remarkable one, which fell on *Emott-more*, nigh *Coln* in *Lancaſhire*, on *Tueſday* the 3d of *June* 1718, about Ten in the Morning; when ſeveral Perſons, who were employ'd in digging *Peat* nigh the Place where this Accident happen'd, upon a ſudden were ſo terrified with an unuſual Voice in the Air, that they left their Work and ran Home, which was about a Mile from the Place: But to their great Surprize, they were intercepted by Water; for a ſmall Brook in the Way was riſen above ſix Feet perpendicular in a few Minutes Time, and had overflown the Bridge.

It is to be obſerv'd, that there was no Rain at that Time on *Emott-more*, only a Miſt, which is very frequent upon thoſe high Mountains in Summer-time. There was a great Darkneſs in the Place where the Water fell, without either Thunder or Lightning, (as I had my Information from an Eye-witneſs.) The Meadows at *Wicolas* were ſo much floated, that the like had not been ſeen in ſeveral Years before, tho' there it was a very bright Day.

I went to view the Place where the Water fell; tho' I believ'd this Inundation might proceed from an Eruption of Water out of the Side of the Mountain; ſuch being not unfrequent, where Lead or Coal have been dug, but neither have ever been ſought for here. The Ground was torn up to the very Rock, where the Water fell, which was above ſeven Feet deep, and a deep Gulf made for above half a Mile, and vaſt Heaps of Earth caſt up on each Side of it, ſome Pieces remaining yet above twenty Feet over, and ſix or ſeven Feet thick. About ten Acres of Ground were deſtroyed by this Flood. The firſt Breach where the Water fell is about ſixty Feet over, and no Appearance of any Eruption, the Ground being firm about it, and no Cavity appearing. The Ground too on each Side the Gulf was ſo ſhaken, that large *Chaſms* appear'd at above thirty Feet Diſtance.

On

Plate I. Vol IV. Part II. Pag. 108.

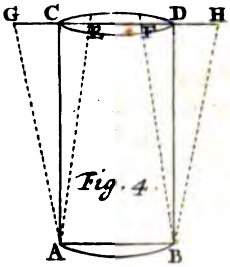


Fig. 4.

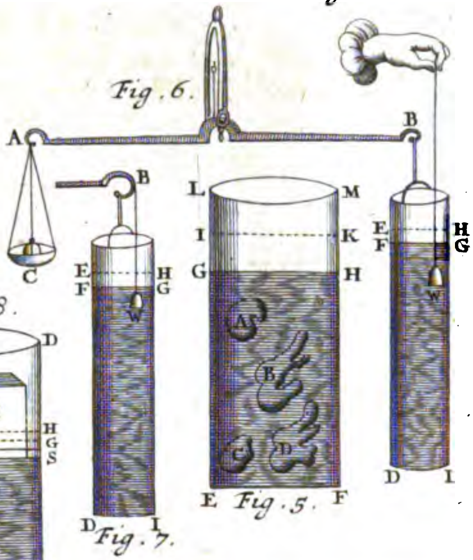


Fig. 6.

Fig. 7.

Fig. 5.

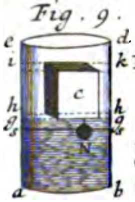


Fig. 9.

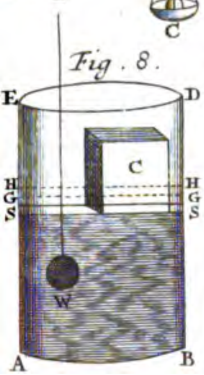
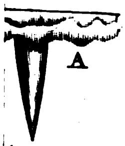
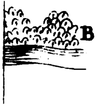
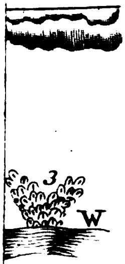


Fig. 8.


ig. 17.





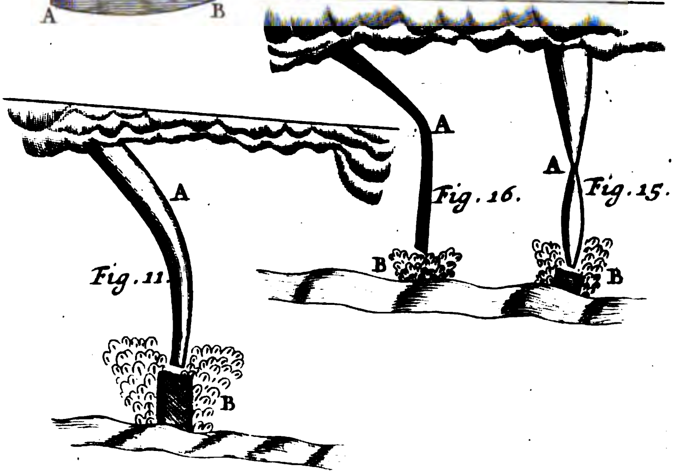
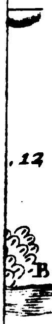


Fig. 11.

Fig. 16.

Fig. 15.


. 12.

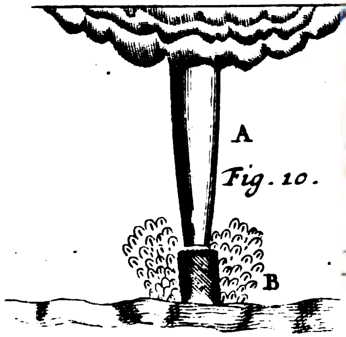


Fig. 10.

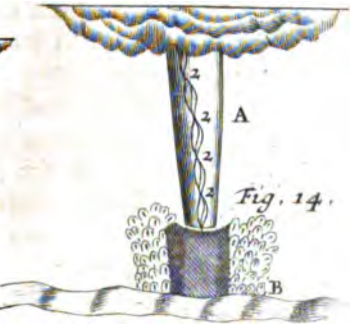


Fig. 14.

A Storm of Hail *in* York-ſhire, *by Mr.* R. Thoreſby. n.335. p.514.

XV. On the *7th* of *June* 1711, there happened a very great Storm of Hail, accompanied with terrible Thunder and Lightning. It begun about *Rotherham* (a little beyond which was ſomething of a Hurricane) where it burnt a noted Tree. About One of the Clock it reached *Wentworth-Woodhouſe*. The Hail-ſtones were from 3 to 5 Inches in Circumference, and ſome ſay larger, which killed ſeveral Pigeons; but the chief Damage done here was in the Glaſs-Windows. In *Waſh* Field, about two Miles from thence, it did vaſt Damage. Some Part of the Field eſcaped, and the *Barley* received no Damage; but the Generality of the *Wheat* was cut off, about half a Yard from the Ground, and the *Rye* about two Feet. The Stubble, tho' green at firſt, turn'd white, that it look'd like a Field newly ſhorn. The *Rye* was afterwards mown, inſtead of ſhearing, and yielded not above a Buſhel of Corn in a Wain-load. Some of the *Wheat* took Root, and grew up. The Breadth of this Storm was about half a Mile, as appear'd by the Effects. In Places adjoining there was no Hail, but large Drops of Rain. A Joyner meaſured one of the Hail-ſtones with his Compaſſes, and it was an Inch and half in Length; but theſe were not Globular, but moſtly Oblong. The Generality of them at *Bolton-upon-Dearne* were of the Bigneſs of Cherries; tho' one was taken up that was an Inch and half in Diameter, and round, not long, and ſomewhat flat, as the others were. Great Quantities of Twigs and ſmall Boughs were beaten off the Trees.

Obſervations *on the* Great Storm, *Nov.* 26. 1703. *by* Mr. W. Derham. n. 289. p. 1530.

XVI. 1.] Having receiv'd from Mr. *Townley* an Account of the State of the Atmoſphere in *Lancaſhire*, during the late great Storm, I ſhall compare his Obſervations with mine at *Upminſter*: I ſhall not give a long Hiſtory of the Devaſtations, *&c.* but ſhall make a few Remarks of a more Philoſophical Conſideration.

To look back then to the preceding Seaſons of the Year, *April*, *May*, *June* and *July* were wet Months in our Southern Parts. In *April* there fell 12, 49 *l.* of Rain thro' my Tunnel. (And about 6, 7, 8, or 9 *l.* I eſteem a moderate Quantity for *Upminſter*.) *In* May *there fell more than in any Month of any Year ſince the Year* 1696, viz. 20, 77 l. *June* likewiſe was a dripping Month, in which fell 14, 55 *l.* And *July*, altho' it had conſiderable Intermiſſions, yet had 14, 19 *l.* Above 11 *l.* of which fell on *July* 28*th* and 29*th* in violent Showers; and I remember the News Papers gave Account of great Rains that Month from divers Places of *Europe*; but the *North of England* (which alſo eſcaped the Violence of the late Storm) was not ſo remarkably wet in any of thoſe Months; at leaſt not in that great Proportion more than we, as uſually they are; as I gueſs from the Tables of Rain, which I had from Mr. *Townley*: Particularly *July* was a dry Month with them, there being no more than 3,65 *l.* of Rain fell through Mr. *Townley*'s Tunnel of the ſame Diameter with mine.

September was a wet Month, eſpecially the latter Part of it; there fell of Rain in that Month 14,86 *l.*

October and *November*, tho' not remarkably wet, yet have been open warm Months for the moſt Part. My Thermometer (whoſe freezing Point is about 84) hath been very ſeldom below 100 all this Winter, and eſpecially in *November*.

I have given this Account of the preceding Diſpoſition of the Year, particularly as to Wet and Warmth, becauſe I am of Opinion, that theſe had a great Influence in the late Storm; not only in cauſing a Repletion of Vapours in the Atmoſphere, but alſo in raiſing ſuch Nitro-ſulphureous or other heterogeneous Matter, which, when mix'd together might make a ſort of Exploſion (like fir'd Gunpowder) in the Atmoſphere. And from this Exploſion, I judge thoſe Coruſcations or Flaſhes in the Storm to have proceeded, which moſt People, as well as myſelf, obſerved, and which ſome took for Lightning.

On *Thurſday*, *Nov.* 25. in the Morning was a little Rain, the Winds high in the Afternoon S. by E. and S. In the Evening there was Lightning, and between Nine and Ten of the Clock at Night a violent but ſhort Storm of Wind and much Rain at *Upminſter*, and of Hail in ſome other Places. There fell in that Storm 1,65 *l.* of Rain. The next Morning, *Friday Nov.* 26. the Wind was S. S. W. and high all Day, and ſo continued. About 12 at Night the Storm awaken'd me, which gradually increas'd till near Three that Morning. And from thence till Seven it continued in the greateſt Exceſs; and then began ſlowly to abate, and the *Mercury* to riſe ſwiftly. The Barometer I found at 12 h. ½ P. M. at 28,72, where it continued till about 6 the next Morning, or 6¼, and then haſtily roſe; ſo that it was got to 82 about 8 a-Clock, as in the Table.

How the Wind ſate during the late Storm, I cannot poſitively ſay, it being exceſſively dark all the while, and my Vane was blown down. But by Information from ſome that were forc'd to venture Abroad, and by my own Gueſs, I imagine it to have blown about S. W. by S. or nearer to the S. in the Beginning, and to veer about towards the Weſt towards the End of the Storm, as far as W. S. W.

The Degrees of the Wind's Strength being not meaſurable, but by gueſs, I thus determine, with Reſpect to other Storms. On *Feb.* 7. 169$\frac{8}{9}$ was a terrible Storm that did much Damage. This I number 10 Degrees; the Wind then W. N. W. Another remarkable Storm was *Feb.* 3. 170½, at which Time was the greateſt Deſcent of the ☿ ever known. This I number nine Degrees. But this laſt of *November*, I number at leaſt 15 Degrees.

As to *November* 17*th* (whereon Mr. *Townly* mentions a violent Storm in *Oxfordſhire*) it was a ſtormy Afternoon here at *Upminſter*, accompany'd with Rain, but not violent, nor ☿ very low. *November* the 11*th* and 12*th* had both higher Winds and more Rain; and the ☿ was thoſe Days lower than even in the laſt Storm of *November* 26*th*.

I have had Accounts of the Violence of the Storm at *Norwich*, *Beccles*, *Sudbury*, *Colcheſter*, *Rochford*, and ſeveral other intermediate Places.

A Table, ſhewing the Height of the *Mercury* in the Barometer, at *Townley* and *Upminſter*, before, in, and after the Storm.

Townley.				*Upminſter.*			
Day.	Hour.	Height of ☿		Day.	Hour.	Height of ☿	
Novr. 25	7	28	98	Novr. 25	8	29	50
	3		64		12		39
	9½		61		9		14
26	7		80	26	8		33
	3		70		12		28
	9½		47		9		10
					12½	28	72
27	7		50	27	7½		82
	3		81		12	29	31
	9		95		9		42
28	7	29	34	28	8		65
	3		62		12		83
	9		84		9	20	07
29	7		88	29	8		25

I have receiv'd an Account from a Clergyman at *Lewes* in *Suſſex*, not only that the Storm made great Deſolations thereabouts, but "That a Phyſician travelling ſoon after the Storm to *Tiſehyrſt*, about 20 Miles from *Lewes*, and as far from the Sea, as he rode pluck'd ſome Tops of Hedges, and chewing them, found them ſalt. Some at *Lewes* hearing this, taſted ſome Grapes that were ſtill on the Vines, and they alſo had the ſame Reliſh. The Graſs on the *Downs* in his Pariſh was ſo ſalt, that the Sheep in the Morning would not feed till Hunger compell'd them, and afterwards drank like Fiſhes, as the Shepherds report. This he attributeth to Saline Particles driven from the Sea.——He

" heareth alſo, that People about *Portſmouth* were much annoyed " with ſulphureous Fumes, complaining they were almoſt ſuffocated " therewith.

—on the ſame *in* Suſſex, *by* J. Fuller, *Eſq*; ibid.

2.] We live ten Miles off the Sea in a direct Line, and yet can ſcarce perſuade the Country People, but that the Sea Water was blown thus far, or that during the Tempeſt the Rain was ſalt, for all the Twigs of the Trees the Day after were white, and taſted very ſalt; as I am inform'd almoſt by every Body, though I did not taſte them time enough myſelf, nor obſerve it, and that not only upon this Hill where we live facing the Sea, but in all other Places within 14 or 15 Miles of the Sea, as well in the Vallies, between which and the Sea are ſeveral high Hills, as on the Hills themſelves.

—on the ſame *by Mr.* Lewenhoek, *ibid.*

3.] On the 8*th* of *December* 1703, we had a dreadful Storm from the South-Weſt, inſomuch that the Water mingled with ſmall Particles of Chalk and Stone, was ſo daſh'd againſt the Glaſs-windows, that many of them were darken'd therewith.

The lower Windows of my Houſe, notwithſtanding that they look to the North Eaſt, and ſo ſtood from the Wind, were ſo cover'd with the Particles of the Water, which the Whirlwind caſt againſt them, that in leſs than half an Hour's time they loſt moſt of their Tranſparency. Suppoſing this might be Sea-water, I view'd theſe Particles with my Microſcope, and found they had the Figure of our common Salt: As to the upper Windows, where the Rain had beat againſt them, there was little or no Salt to be found ſticking upon them.

During the ſaid Storm, and about eight of the Clock in the Morning, I caſt my Eye on my Barometer, and obſerv'd that I had never ſeen the *Mercury* ſo low; but half an Hour after the *Mercury* began to riſe, though the Storm was not at all abated, at leaſt to any Appearance; from whence I concluded the Storm would not laſt long, which accordingly ſo happen'd.

Some think that the ſcattering of this Salt Water will do a great deal of harm to the Fruits of the Earth; but I am of Opinion that a little Salt ſpread over the Surface of the Earth, eſpecially where it is heavy Clay-ground, does render it fruitful; and ſo it would be if the Sand out of the Sea were made uſe of to the ſame Purpoſe.

—on the ſame, *by the* ſame, n. 295. p. 1793.

4.] From the Waves of the Sea, which the Winds had carried over our Meadows and Orchards, I preſaged a fruitful Year. Since that ſeveral Perſons concern'd in Tillage and Grazing have aſſured me, that they never knew ſuch a plentiful Year for Graſs, as alſo for Peaſe and Beans, as the laſt Summer was.

The Hiſtory *of the* great Froſt, 1708, *by Mr.* W. Derham. n. 324. p. 454.

XVII. The Society having put into my Hands ſome Papers relating to the late *great Froſt*, and having myſelf receiv'd Accounts thereof from my Friends at home and abroad, I ſhall endeavour to give an Account of the *Degree* and *Effects* of this remarkable *Froſt*.

The Degree of the Froſt in England.

As to the *Degree* of this Froſt, I believe it was greater (if not more univerſal alſo) than any within the Memory of Man. The greateſt that hath happen'd within our Memory, was the *Long Froſt* in 1683; but the late Froſt, although of ſhorter Continuance, was more intenſe than that. My Thermometer was lower on *December* 30. (†) than it had ever been ſince 1697, when I firſt began my Thermometrical Obſervations: The ſelf-ſame Thermometer in our Repoſitory in *Greſham-College* was lower than ever it was before: [The Particulars of its greateſt Deſcents are theſe; *January* 26. 1696. 41 *Gr.* *January* 5. 1683. 40 *Gr.* and *January* 3. 1708-9. 43 *Gr.*] And laſtly, that in another ſelf-ſame Glaſs in *London*, [Mr. *J. Patrick*'s] the Spirits were four or five Degrees lower than in 1683.

In *London* the greateſt Contraction of the Spirits was on *January* 3. which was an exceſſive cold Day at *Upminſter* alſo: But the far greateſt Contraction with us was on *December* 30. before. The Reaſon of the Difference is, becauſe my Thermometer is always abroad in the open Air, where no Sun-ſhine toucheth; but thoſe two *London-Glaſſes* are within Doors, in Rooms where no Fires are made. And it is eaſy to obſerve, that the Froſt doth not preſently exert its greateſt Force, nor ſo ſoon abate its Force within Doors, as without.

Of this Intenſeneſs of the Cold with us, I have receiv'd Confirmations from other Places in the Southern Parts of our Iſland.

The Deſcent of the Spirits in my Thermometer on *December* 30. was within One tenth of an Inch as great as the Deſcent effected at another Time (and that in a *Cold Day* too) with artificial Freezings performed both with Snow and Salt, and alſo Snow and Spirits. Both which Mixtures I have ſeveral Times made uſe of, and find them nearly of equal Power: If any Difference be, I have ſometimes thought the Preference due to the Mixture of Spirit of Wine with the Snow.

Degree *of the Froſt in* Scotland.

Although the Froſt was ſo rigorous in the Southern Parts of our Iſle, yet the Northern felt little thereof; as I have been certified by Perſons that have come from thence, as well as by ſeveral Letters. Dr. *Sloane* writes to me in general, that he hath received many Informations from thoſe Parts, which do all agree that the Winter was no way extremely cold there, but as other Winters. The Lord *Biſhop*

of

(†) *Vid.* Supra S. XI.

of *Carliſle* in a Letter to Dr. *Woodward*, ſays, " In *January* laſt, I had " a ſufficient Occaſion to take Notice of the Froſt and Cold being " more intenſe in the Southern Parts than here, and the Snow much " thicker. I began my *London* Journey on the 26th of that Month, " three Days before the Thaw, and aſſure you that for ſeveral Miles " (near the Banks of the River *Eden*, in both the Counties of *Cumberland* and *Weſtmoreland*) my Horſes hardly ever trod upon Snow. " When we came to *Stanemoor*, on the Confines of *Yorkſhire*, we found " the Ground covered pretty thick, and the deeper ſtill the farther " we came to the South. None of our Rivers or Lakes were frozen " over; and the extraordinary Flocks of Swans that reſorted hither " (nothing of the like having been ſeen by the eldeſt Man living) " was a ſure Argument that the Temperature of Climates was ſtrangely inverted."

From *Edinburgh*, Sir *Robert Sibbald* ſays, " I can learn no extraordinary Effects of the cold Seaſon here. It was a long Winter: The " Cold came early in *Octob.* and continued till near *May*. There was " much Snow, which lay long upon our South Hills near this Place. " We had not much Snow to ſpeak of, and it laſted not long."

In Ireland.

In *Ireland*, I am inform'd, the Froſt was very favourable, by a Letter from Mr. *S. Molyneux*, who ſays, " They had there an harder Winter " than uſual, but judgeth they ſuffered not ſo much as their Neighbours: They had two or three pretty hard Froſts, and ſome Snow, " but not of any remarkable Continuance, as he remembers."

Degree *of the Froſt in other* Parts *of* Europe.

In Switzerland.

(*) *Vid.* Supra. S. XI.

In the Compariſon made before between Dr. *Scheuchzer*'s Obſervations at *Zurich*, and mine here, I ſaid (*) That he noted the Cold to have been exceſſive there; but whether more than uſual he ſaith not. But by a Letter I have lately ſeen from his Brother, it appears to have been in as great and unuſual Exceſs there, as here it was with us.

In Italy.

In that Paper too I obſerved, to what Exceſs the Froſt arriv'd in *Italy*, *viz.* " That the Cold there was ſo great, that for 20 Years paſt, " they had not been ſenſible of a greater; and on *Twelfth-Day* it wanted but half a Degree of the Extremity."

In Denmark.

As to the *Northern Parts*, Dr. *Woodward* tells me, that in a Letter he received from Mr. *Otho Sperling*, from *Copenhagen*, he calls it *Hyems Atrociſſima*. And I find it noted in the Minutes of the *Royal Society* of *May* 4. 1709. " That Dr. *Judichar* ſaid the Ice was frozen " in the Harbour of *Copenhagen* 27 Inches; and that *April* 9. " *N. S.* People had gone over between *Schonen* and *Denmark* on the " Ice." Which Accounts give me a better Opinion of ſome Papers I have by me, which were ſhew'd to the Society, concerning the Froſt at *Copenhagen*, ſaid to be taken from the Obſervations of Mr. *Romer*. 'Tis ſaid there, " That ſuch a Froſt hath "not been known in the Memory of Man in theſe Countries, and "that the Froſt on *January* 7. and *February* 23. 170$\frac{8}{9}$. did very nearly "approach the Point of Artificial Freezing."

In the Northern Parts of *Germany* it was much the ſame; of which I have a printed Account. The Title of the Book is, *Conſideratio Phyſico-Mathematica Hyemis proximè præterlapſæ, &c.* being an Academical Exerciſe, perform'd in the Univerſity of *Hall*, *June* 13. 1709. by *G. Remus*, a *Dantzicker*, and printed at the ſame Place [*Halæ Magdeburgicæ.*] This Diſſertation being, I ſuppoſe, in but few Hands, I ſhall give a ſhort Account of it. —*in* Germany.

The Author having complain'd of the Defects of Meteorology, and Meteorological Inſtruments, and given ſome Directions concerning obſerving the Winds, *&c.* tells us, he had the Help of the Obſervations of three eminent Perſons in his Diſſertation about the Winter, of Dr. *Wolfius* of *Hall*, Dr. *Hamberger* of the Univerſity of *Jena*; and Reverend Mr. *Teuber* of *Ciza*. The Winter he diſtributes into five Periods. The firſt of which he begins at *October* 19. 1708. at which Time he ſays the cold Weather began with them, the Northerly Winds then blowing, and froſty Weather accompanying it. But with us at *Upminſter*, it began ſooner: For all the latter End of *September*, the Winds were Northerly, and an Hoar-Froſt on *Michaelmas*, and the following Days. After which, a great Part of *October* to the 23*d* Day, my Regiſter ſhews the Weather to have been, for the moſt part Hoar-froſty, or Froſty, very agreeably to Mr. *Remus*'s Obſervations. The End of this firſt Period he placeth on *November* 3. the ſame with our *October* 23. *O. S.* their Stile, I perceive by divers Compariſons, and Hints in his Paper, being the New Stile.

As to his next Period, which with its Interval takes in *November* and *December*, I find a pretty deal of Agreement between his Obſervations and mine, the Weather often being warm, or cold here, as it was there, and the Winds alſo not very different. Only I obſerve the Cold in one Place commonly to precede the other. Alſo the furious Wind, that he ſaith blew the Night before *December* 13. was not perceivable here 'till the ſecond Day after. *viz.* *December* $\left\{\begin{matrix}14\ N.\ S.\\ 3\ O.\ S.\end{matrix}\right.$ about Noon: At which Time it had much ſpent itſelf, and was only a briſk Eaſterly Wind, but no Storm.

The third Period he begins on *January* 5. Of which he ſaith, *The Scene was preſently changed, and to the Aſtoniſhment of all* Europe *a Period began, which was very remarkable for its unuſual Cold.* The very ſame $\left\{\begin{matrix}Jan.\ 5.\\ Dec.\ 25.\end{matrix}\right\}$ the Wind and Weather began here to change, as there he ſaith it did, and the Cold alſo to increaſe. The moſt remarkable Depreſſions of the Spirits there, may be ſeen with mine in this Table.

Day of the Month. O. S.	*Degree of the Thermometer at* Hall, *at* $10^{h.}$ *p. M.*	*Degree of the Thermometer at* Upminſter, *at* $9^{h.}$ *p. M.*
Dec. 27		65
28	84½	75
29	84½	58
30	92½	45
31	100	52
Jan. 1	Totus intra	63
2	Sphæram.	54

It is to be obſerved that the Scale of their *Thermometer* runs downwards from ſome Point above, down towards the *Ball*. But the *Ball*, or the Bottom of the Stalk, being a certain Place that all Thermometers agree in, and every one is acquainted with, I therefore make the Degrees of the Scale of my Thermometers to begin at the Top of the Ball, or (which is all one) at the Bottom of the little Tube, or Stalk, and ſo reckon upwards; every Degree being one Tenth of an *Engliſh* Inch; the *Freezing-Point* in my old Thermometer (here noted) at 82 *gr.* equal to 8 Inches two Tenths from the Ball; and the moſt *intenſe Cold* at 44 *gr.* But in my later Thermometers (which I now uſe, and are much nicer than my old one) the *Freezing-Point* is at 100 *gr.* ten *Engliſh* Inches from the Ball, and the moſt *intenſe Froſt* near to, or juſt in the Ball.

It may from the foregoing Table be perceived, that the Froſt kept a pretty equal Pace in both Places at its Beginning. And my Notes give me Reaſon to think it did the ſame the greateſt Part of its Duration: But I cannot be very ſure thereof, my old Thermometer (the only one I then had) happening to be broke on *January* 11. For which Reaſon I am unable to give ſuch another Thermometrical Table of his next Period, as I have done in this.

This third Period he makes to end *January* $\left\{\begin{matrix}25\ N.\ S.\\14\ O.\ S.\end{matrix}\right\}$ with a Weſterly Wind, and a Thaw, which held for a few Days. With us the Wind was Southerly at the ſame Time, and a Thaw accompanying it for a few Days likewiſe.

The fourth Period he begins *January* $\left\{\begin{matrix}31\ N.\ S.\\20\ O.\ S.\end{matrix}\right\}$ in which I obſerve there is a great Agreement between our Obſervations as to the Cold; and thoſe Days on which he noteth the Weſterly Winds to have been ſtrong, it was the ſame here. And ſome Agreement alſo, but leſs, is in the coaſting and ſhifting of the Winds throughout this Period.

The fifth and laſt Period he placeth between *February* $\left\{\begin{matrix}17\\6\end{matrix}\right.$ and *March* $\left\{\begin{matrix}17 \text{ N. S.}\\6 \text{ O. S.}\end{matrix}\right\}$ In this, he ſays the cold Weather returned, and continued long: And the ſame it did with us. But as to the End of this Period, I find ſome Difference, and ſome Agreement between our Obſervations. The Snow was more with them than us; the Winds changed with us from the Eaſterly Points, to the Weſterly and Southerly, a Day or two ſooner than with them; then agreed with them; and ſoon after veer'd about to the Eaſterly and Northerly, as it did with them. And I obſerve, that when the Winds agreed in both Places, my Notes ſhew the Wind to have been of ſome Force here.

As to the Warmth of the Weather all this time, I find a pretty deal of Agreement; only as the Wind changed two Days ſooner here, ſo we had the mild Weather, he mentions, two Days ſooner: Then it grew colder here, as he ſaith it did with them. And whereas he noteth *April* $\left\{\begin{matrix}13 \text{ N. S.}\\2 \text{ O. S.}\end{matrix}\right\}$ to have been the firſt Day on which the Spirits roſe to the Point of Warmth, I found by my Thermometer the Day before to have been as warm as that, as alſo were the following Days; and each of them warmer than had been all the preceding Winter; but yet that we had divers warm Days before that Time, particularly *March* 12, 13, 14, 18, 19, 28. *O. S.* were warm Days, but the reſt in that Month for the moſt part cold.

The Effects *of the* Froſt —*on* Fluids.

The Waters were the firſt Thing that felt the dire Effects of this Froſt. And theſe were in many Places frozen to an extraordinary Depth; although I hardly believe to that Depth, as in the Long Froſt in 1683. Of which Froſt we have a ſufficient Inſtance in our River of *Thames*; whoſe Waters were ſo frozen, that above Bridge, 'tis well known, many Booths were erected, Fires made, and Meat dreſs'd; and on *January* 10. $168\frac{3}{4}$, I ſaw a Coach and two Horſes drive over the River into *Southwark*, and back again, a great Number of People accompanying it. But this laſt Winter the Caſe was greatly different, according to the Account I receiv'd from Mr. *Lowthorp*, who ſays, "He "ſaw ſeveral People croſs the *Thames* at ſome Diſtance above the "Bridge: But that was only towards Low-water, when the great "Flakes of Ice that came down, ſtopp'd one another at the Bridge, "till they made one continued Bed of Ice from thence almoſt to the "*Temple*. But when the Flood came, the Ice broke, and was all car-

" ried with the Current up the River. I was told the like happened " between *Weſtminſter* and *Lambeth*, a little above *Whitehall.*

As for other Waters, they alſo had their Share; eſpecially where they lay expoſed to the Northerly and North Eaſterly Winds. The Sea-waters were cover'd with Ice in many Places near the Shore, in Harbours, and where they lay calm and ſtill. Of this I have already given a pregnant Inſtance in the Harbour of *Copenhagen*, and the Sea between *Denmark* and *Schonen*. And in a Letter from Dr. *Newton*, he tells me, " The Sea was frozen both on the Coaſt of *Genoa* and *Leg-*" *born.*

As for the Northern Parts of *Germany*, the laſt cited Diſſertation gives this Account of its Effects on Fluids: *Water was frozen into Ice beyond the uſual Depth, and other Liquids appear'd to be congealed, which in Midſt of Winter are thought to be out of Danger of freezing. A Fountain in a certain Village of* Sileſia, *which tho' at other times was found to be cool in Summer and warm in Winter, yet this Winter it was cover'd with pretty thick Ice, to the great Wonder of every one. The publick News have ſometimes told us of hot Baths converted into Ice. Tho' this cannot happen to thoſe that are very hot- - - - at* Hall *we ſaw Iceicles adhere to the Salt Fountains, which is reported not to have happen'd for an Age.* D. Breynius *aſſures me by Letter, that the Sea itſelf was cover'd with Ice on the 8th of* April, *as far as his Eye could reach. He expoſed a Lixivium to the Air, which had been plentifully impregnated with Pot-aſh, which by thoſe who had uſed it for many Years was affirm'd never to freeze; yet in a ſhort time it was found converted into Ice. He adds, that a certain Friend of his had obſerved, that a dephlegmated Spirit of Tartar had froze. The Obſervations of* Hall *relate, that Spittle hardly diſmiſs'd from a Man's Mouth became Ice. The Rivers were froze thrice, even thoſe which for their Rapidity were always Proof againſt freezing.* Thus far D. *Remus.*

Theſe Effects, I am apt to think, the Waters felt not only in *England, Denmark, Germany, France* and *Italy*; but in all the *Northern World* alſo, excepting *Scotland, Ireland*, and probably ſome other Iſlands, or Places near the Sea; altho' even ſome of theſe appear from the foregoing Account to have been great Sufferers too. This Univerſality of the Froſt, I ſuſpect from the Multitudes of divers kinds of Birds (utter Strangers to theſe Parts, and many of them Inhabitants of the Northern colder Countries) which were ſeen and kill'd in many Parts of *England*. In our *Eſſex-Marſhes*, we had many wild Swans, Brent-Geeſe, many of the rarer Gull-kind, and divers other ſorts of Birds, utter Strangers to theſe Parts. Mr. *Bellers* gave Dr. *Woodward* this following Catalogue of Birds kill'd within four or five Miles of *Coln St. Aldwins*, or *Edwins*, in *Glouceſterſhire*, between the Beginning of *November*, and the latter End of *March* 1708, which he ſaith are never found there in moderate Winters.

1. *Lanius cinereus major*, the greateſt Butcher-Bird, or Mattageſs; ſometimes ſeen in *Derbyſhire*, but commonly in *Germany*, as Mr. *Willoughby* ſaith. 2. *Fringilla montana*, the Brambling. 3. *Numenius, ſive Arquata*, the Curlew. Theſe Birds, though Strangers to the inland Parts, I have ſeen common enough on the Sea-coaſts of *Eſſex*: And Dr. *Woodward* ſays, he ſaw them ſeveral Times this laſt Winter at the *Poulterers* in *London*. 4. *Gallinula Erythropus major*, the Red-ſhank, or Pool-Snipe. 5. *Gallinula Hypoleucos Geſneri*, the Sand-piper. 6. *Schœniclos*, the Stint. 7. *Corvus aquaticus minor, ſive Graculus Palmipes*, the Shag. 8. *Merganſer*, the Gooſander. 9. *Mergus cirratus longiroſter*, the Dun-diver. 10. *Mergus major cirratus*, the Smew, or white Nun. 11. *Colymbus major*, the Greater Loon. 12. *Larus major*, the Greater Gull. 13. *Cygnus ferus*, the Elk, or Hooper, or wild Swan. 14. *Brenta*, the Brent-Gooſe. 15. *Anas niger Aldrovandi*; ſeldom ſeen in *England*, but frequent in *Norway*. 16. *Tadorna*, the Shell-Drake, or Burrough-Duck. 17. *Anas Fuligula prima Geſneri*, the Tufted-Duck. 18. *Anas fera fuſca Geſneri, Penelops Veterum*, the Poker. 19. *Anas Platyrhynchos mas Aldrov.* the Golden-Eye. 20. *Anas Platyrhynchos roſtro nigro & plano*, the Cadwall.

Effects of the Froſt on Animals.

In the Diſſertation before-cited, we are told, how Animals ſuffered both with them, and in other Places; "That the Freſh-water *Fiſh* were every where kill'd in their Parts, and that a vaſt Deſtruction befel their *ſmall Birds*. Both which, he is inform'd, happen'd in his own Country alſo at *Dantzick*. Nay, ſome did not ſtick to affirm, that they ſaw Birds, as they flew along, drop down out of the Air, their Strength failing: That the *Luſatia Letters* ſaid, many Cows were frozen to Death in their Stalls. And many Travellers on the Road were ſome quite frozen to Death, others loſt their Hands, Feet, Noſes or Ears; and others fainted, and were in great Danger of Life or Limb, when brought too ſoon near the Fire. Of theſe Particulars, he gives divers Inſtances from their News Papers; of two Gentlemen, and a Smith in *England*, and above 60 Men, and many Cattle near *Paris*; and the like at *Venice*, and 80 *French* Soldiers near *Namur*, all kill'd on the Road, with the Cold." Whether any ſuch Perſons periſhed on our Roads in *England*, I have not heard: But we were told of ſome that did; particularly ſome Poſt-Boys, and, I think, ſome Drovers. Our Freſh-water Fiſh were, many of them, deſtroyed, in Ponds that were ſhallow, and eſpecially if long frozen over; ſome for want of Air, where the Ponds were not kept open; and ſome with the cold Air at the Holes in the Ice, where in great Numbers they came to get Breath. On the *Italian* Coaſt ſome of our "Mariners on Board our Men of War, died of the Cold; and ſeveral loſt Parts of their Fingers and Toes: As Dr. *Newton* informs me.

But the greateſt Sufferers in the Animal-Kingdom, were *Birds* and *Inſects*. *Robin Redbreaſts*, which before the Froſt were numerous, are ſince that very ſcarce about us; and notwithſtanding their Recruits in the following Summer, yet even ſtill, in this ſucceeding Winter, their Scarcity remains. *Larks*, both *Wood* and *Sky-Larks*, became, in a Manner, Rarities in our Country the following Spring and Summer; nor are they as yet become ſo numerous as heretofore. But whether this was an univerſal Calamity that befel that Family of ſmall Birds, or whether it only happened to our *Eſſex-Larks*; or whether they were not driven from theſe Parts by the Froſt, I cannot ſay; becauſe I have been told, that in ſome other Counties of *England*, which abound in large common plough'd Fields, and where Larks are commonly more numerous than about us, they have had large Flights of Larks this preſent Winter 170$\frac{9}{10}$. But I have enquired of the *London* Poulterers, and thev tell me, they have Larks from almoſt all Parts of *England*, and have not this following Year receiv'd a Quarter, ſcarce a tenth Part, of the Larks they uſed to have; by reaſon the Froſt kill'd them, as the Bird-Catchers ſay.

In the *Inſect-Tribe*, I have particularly obſerv'd the *Death-Watch* to be great Sufferers; notwithſtanding that Inſect's great Precaution, and Art, to ſecure itſelf againſt the hard Weather, in dry Places within Doors, under downy light Duſt, *&c.* Few of them appear'd the following Summer; and in Places where they uſed in *July* to be very ſonorous with their ticking Noiſe, only now and then one was heard; a manifeſt Sign of their being either kill'd, or render'd leſs fertile and venereous.

Effects of the Froſt on Vegetables.

But among all the Sufferers by the Froſt, the *Vegetables* were the moſt univerſal; few of the tender Sorts eſcaping. About us, *Bays*, *Roſemary*, *Cypreſſes*, *Myrtles*, moſt of the *Phillyrea's*, even *Junipers*, among Shrubs; and *Artichokes*, *Colly-Flowers*, and a great many other Olitory Plants, ſuffer'd greatly. By Enquiries made on Purpoſe among the *London Gardeners*, I have been inform'd, ſome of them have loſt to the Value of 80*l.* 100*l.* 200*l.*

But the moſt exact Account I have met with, is from Mr. *Ja. Bobart* of the *Oxford* Phyſick-Garden. He takes Notice, that the Damages of this Froſt do not come up to thoſe in 1683; which Froſt being of longer Continuance, cleft the *Oaks*, and Bodies of the *Vines*, &c. But in the laſt Froſt there were Intervals of Relaxation, beſides ſeveral conſiderable Snows, which prov'd a good Guard to many Plants. But the Snow melting, and the Cold withal continuing, prov'd of evil Conſequence to many bulbous and tuberous Roots, and abundance of other Things. " But (he ſays) the ſharp, dry, and cutting Winds " from the North, and North-Eaſt, were deſtructive to many of the

“ Ornaments of our Gardens, which before ſeem'd to be almoſt
“ naturaliz'd to our Clime; as *Cypreſs*, *Bays*, *Roſemary*, *Alaterni*, *Phil-*
“ *lyrea*'s, *Arbuti*, *Lauruſtines*, &c as alſo to moſt of our fruteſcent
“ Herbs, ſuch as *Lavenders*, *Abrotonums*, *Rue*, *Tyme*, and divers others
“ of ſuch Race, eſpecially ſuch as had their Heads above the kind
“ Covering of the Snow. And not ſuch Exoticks only, but ſome
“ of our own Natives, as is viſible in moſt of our *Furze-fields*,
“ and divers *Hollies*, eſpecially of the finer ſtrip'd Race, have felt the
“ Smart of the Rigour of the Seaſon, by the Loſs of their Leaves,
“ and ſometimes their Lives.

“ And what hath been more obſervable this Year, than in others,
“ is the Sap of our finer mural Fruit-Trees, as of *Peaches*, *Necta-*
“ *rines*, *Apricocks*, &c. was ſo congeal'd and diſorder'd, that it prov'd
“ ſtagnated in the Limbs and Branches, and equal to Chill-blains in
“ Human Bodies; which, in too many Parts of the Tree, turn'd to
“ ſo frequent Mortifications, that it is very much to be doubted, whe-
“ ther ſufficient Vigour is ever to be expected from them, to be worth
“ their ſtanding, notwithſtanding their weak Endeavours of ſhoot-
“ ing.

“ And it is no leſs obſervable, that the very Buds in theſe finer
“ Trees, as well Leaf-Buds, Bloſſom-Buds, (which are but the Ova-
“ ries of the ſucceeding Fruits) were quite kill'd, and dry'd into a fa-
“ rinaceous Matter, by the too great Sharpneſs of the Cold, before
“ they grew out, though Life remain'd in the Branch.

“ The *Plumbs*, being more hardy, produc'd their Bloſſoms well
“ enough; but through the chilling Wets, which happen'd too plen-
“ tiful about that Time, and the great Defect of nutritive Warmth,
“ they grew weak; with their little Stalks, or Pedicles, languiſh-
“ ing, and turning yellow, generally dropt off, and came to no-
“ thing.

“ It might reaſonably have been ſuppos'd, that ſuch conjoin'd Cold,
“ with repeated Wets, ſhould have deſtroyed the injurious *Inſects*,
“ which uſually infeſt the firſt Product; but even in this Year, they
“ have prov'd vivid, in too great Plenty, among the *Apples* and *Pears*
“ (eſpecially the former) whoſe Bloſſoms, as well as Leaves, have been
“ a Pabulum for theſe voracious *Erucas*, whoſe Eggs lay dormant all
“ the Winter, ſo dry in their Bags, that there were ſo many eſcap'd
“ from being frozen, that in many Places they prov'd enough to de-
“ ſtroy the whole Verdure.

“ *Fig-Trees*, whoſe ſofter Texture was more eaſily penetrated, have
“ ſuffered much, moſt of them being cut down.

“ Many *Exotick Greens*, and rare Plants coming from *Africa* and
“ other warm Regions, have mightily ſuffered, eſpecially in ſuch Stoves
“ and Conſervatories as had not Fire enough.

What he obſerveth concerning the Deſtruction of *Wheat*, was, I believe, a general Calamity, as alſo the Particulars he takes Notice of much the ſame in other Places too, *viz.* " Where the Land was poor, " and coldly expoſed, there the *Wheat* was kill'd; that many Lands " of Wheat eſcaped tolerably well on the warm Side, when the other " Side was quite kill'd with the Extremity of Cold.

By the *warm and cold Sides*, I ſuppoſe our Obſerver means the ſunny and ſhady Sides. But with us the Wheat ſuffer'd rather more on the Southern, ſunny Side, than the Northern; I ſuppoſe by reaſon the Ground was ſomewhat open'd by the Sunſhine, and the covering of Snow melted, and Way thereby made to the Severity of the nocturnal Froſt. Upon which Account I have heard it ſaid by ſome Obſervers, *that Vegetables ſuffered more the laſt Winter from the Sun, than the Froſt*.

In *Eſſex* alſo, I obſerved many ſmall Fields of three or four Acres of Wheat, to eſcape pretty well, where fenced with thick high Hedges againſt the cold Winds, eſpecially where they were cover'd long with Snow; at leaſt they came off better than other Parcels of Land expoſed to the Winds, that diſlodg'd the Snow, and aggravated the Cold alſo. So at *Upminſter*, the beſt Pieces of Wheat were ſuch, I obſerv'd, as lay on gentle Deſcents facing the Weſt or S. W. eſpecially when guarded on the Eaſtern Side with a Hill, or a Wood; which fenced off the cold piercing Eaſterly and North Eaſterly Winds.

Not only *Shrubs* and *Plants*, but the *larger Trees*, have in ſome Places had their Share of Suffering too. But it was obſerv'd by ſome Perſons of the *Society*, that the Calamities which befel Trees, aroſe not purely from their being frozen, but principally from the Winds ſhaking and rocking them at the ſame Time, which rent and parted their Fibres.

Theſe have been ſome of the moſt remarkable Effects of the Froſt on the *Vegetables* of the more *Southerly* Parts of our Iſland, the *Northerly* eſcaping better. From *Edinburgh*, Sir *Rob. Sibbald* ſays, " The " Corn did not riſe, and ripen, ſo ſoon as wont; but there hath been " a plentiful Harveſt, well brought into the Barns and Yards. And " the Price of Victuals (which was high) falls lower daily. There " was no greater Number of thoſe who died, than was uſual during " the Winter formerly.

As to other Places, I find the Effects were, in the more Southerly Parts of *Europe*, much the ſame on their Vegetables as on ours. In *Italy* Dr. *Newton* ſaith, " Almoſt all the *Lemon* and *Orange-Trees*, " with thoſe of the like Kind, are deſtroyed in this Country by the " Froſt, and a great many *Olive-Trees*. The Leaves of the *Bay-Trees* " have the ſame Colour now, as all others have when they are falling " in *October*. Beſides which, there are two other Accidents he tells me of, owing probably to the Froſt. One happen'd at *Florence*, where, " on the ſide of a Hill were formerly many Buildings, " which twice falling down, by the Earth giving way, a Wall was " erected in the Time of this Great Duke's Grandfather, with an Inſcription on the Wall, which ſeparates the Ground from the next " Street, that for the future no Perſon ſhould build there. After the " Great Froſt, this Wall hath fallen down too. The Hill is full of " Stones, and they will have it, that as thoſe increaſe, the Ground is " puſh'd forward, and thereby thrown down." But I am apt to think, the Froſt might have a great Concern herein.

The other Accident was at *Piſa*, " where, upon the melting of the " Snows, and the great Rains which fell after the Froſt, altho' the *Arno* " did not ſwell over the Banks at *Piſa*, yet the Water at ſome Diſtance " from the River, in a middle Row of Houſes betwixt the River and " the great Street on the Northſide, with great Violence broke out, and " if it had not been immediately perceiv'd, and the Breach ſtopp'd by " the throwing in of a great Quantity of Bricks and Timber, that Part " of the Town might have been in Danger of being drowned, where " the *Palace*, and the *Publick-Schools*, or (as they call it) the *Sapienza* " ſtand.

Dr. *Mich. Angelo Tilly* tells me from *Piſa*, " That the Froſt hath deſtroy'd a World of Trees both in City and Country about them.

In *Switzerland*, among the high *Alpine* Ridges, they felt dire Effects of the Froſt; yet ſome Places eſcap'd. Of which Dr. *Woodward* imparted to me the following Account from Mr. *John Scheuchzer*, " Some " Places that were defended towards the North by very high Mountains, did not feel thoſe dreadful Effects, which our Trees ſuffer'd laſt " Winter, eſpecially our Walnut-trees and Vines. At *Veſena* near the " Lake *Rivarius*, the Trees and Vines ſuffer'd no Damage, ſo that the " Vintage is good there, but we have none. The Walnut-trees " were loaded with Fruit, and other Trees likewiſe, as if they had grown " in a Climate different from their Neighbours. The Village *Vettis* is " ſituate at the Bottom of *Galanda*, a very high Mountain on the Confines of the *Griſons*. The Inhabitants of this aſſure us, that they hardly ever knew a milder Winter; when on the contrary the Inhabitants " of the next Village *Valentia*, lying near the *Fabarian* Baths, were much " afraid leſt all the *Vettians* ſhould periſh with Cold, all Intercourſe between them being intercepted by the hard Weather. Alſo the Woods " which were expos'd to the North Wind, which were planted with " hardy Trees, ſuch as Firs, Yew-trees, and Larch-trees, became burnt " up, ruſty, and ſtript of their Leaves.

As to the Northerly Parts of *Germany*, the Caſe was there after the manner it was with us; as Mr. *Remus* informs us. " The cold Weather deſtroy'd the Trees and Shrubs in great Numbers, eſpecially ſuch " as appear'd above the Surface of the Snow. The Cherry-trees, Apple-" trees, and Plumb-trees deſpiſed the Severity of the Winter. Our

“President (Dr. *Wolfius*) apply'd many Particles of the Boughs to his Microſcope in the Month of *March*, but could not perceive that any thing was wanting to the Intireneſs and Turgidneſs of the Fibres. There were Plenty of Bloſſoms on the Cherry-trees, few on the Apple-trees, &c. The Almonds, Peaches, and Apricocks, of whatever ſort they were, very rarely eſcaped. The Pears ſuffer'd much. Such Vines were preſerved, as were cover'd by the Earth, and thereby ſecured from the Cold; but ſuch as were neglected and not ſufficiently defended were all loſt. This we ſaw, and were inform'd of it by the News. But we ſhall relate what the Preſident took notice of. When we could viſit our Gardens ſoon after the Equinox, the Snow being melted and the Ice thawed; the Bark, the Wood, and the Pith of ſuch Trees as had been ſpoiled by the Froſt, eſpecially the Pears and the Apricocks, were grown black, ſo that many pull'd them up. When we apply'd to our Microſcopes ſome Pieces of ſuch Boughs as had grown the laſt Summer, we found the little Fibrils torn as if the Wood had been rotten. But in other Parts of the Branches no ſuch Diſruption was obſerved, only there was no Greenneſs or Sap. For as about the middle of *April* the Trees were cheriſh'd by the Heat of the Sun, in the Apricock Trees many new Buds put forth from the old Wood, and in ſome from the younger Wood, where the Bloſſoms ought to grow; in ſome there was no Succor. In the Pears all the Buds put out, and Bloſſoms grew; yet not ſo vigorous as uſual, and leaving no Rudiments of Fruit. At that Time the Bark obtain'd its full Greenneſs, blacker proceeded from the Center of the Pith towards the outſide, the Subſtance of the Wood recover'd its Whiteneſs. The Fibrils of the new Year were black ſtill, yet when ſeen through a Microſcope they ſeem'd to abound with Sap, not otherwiſe than the ſame Fibrils of the Cherry-tree or Apple-tree, which the Froſt had left untouch'd. The Pith under the Buds was tinged with an unuſual Blackneſs, yet the Root of the Bud, when puſh'd on into a Succor, appear'd through the Microſcope to be very green and turgid. Now it is very remarkable, that as the Froſt had ſpared the Plumbs, ſo it alſo ſpared the Buds of the Apricocks, that were grafted into the Bark of the Succors of the Plumbs, which now grew up into tall Leaves according to Trees of its Kind, in which the Froſt had not ſpared ſo much as one Bud.

As to the *Cauſes* of this Great Froſt, they are, I confeſs, to me ſo very much hidden, that I intended wholly to have paſs'd over that Matter. But Mr. *Remus* having ingeniouſly enquir'd into them, I ſhall briefly give his Opinion.

The Cauſes of the Froſt.

The Fountain of Heat enjoy'd by the Earth, being the Sun, and that Heat being not always the ſame, he enquires into the Reaſon why it is not ſo. The Variation of the mutual Diſtance between the Earth and Sun at the Apogee and Perigee; the Mutuation of the Earth's Place in Reſpect of the Heavens, or its being juſtled at a greater Diſtance from the Sun, and the Obſtruction of the Solar Rays by the Spots on the Sun, he rejects. And as to the true Cauſes, having aſſign'd good Philoſophical Reaſons for the perpendicular warming more than the oblique Rays, for the Wind cooling the Air, and the North and Eaſt more than other Winds, *&c.* he then enumerates his Cauſes in theſe Words: *On the Sun's Part is required a very great Diſtance from the Zenith, and a ſmall Continuance above the Horizon. On the Earth's Part is required an Atmoſphere full of Exhalations, and abounding with Clouds: Alſo Eaſterly and Northerly Winds, and eſpecially violent ones. But what is moſt of all neceſſary, that the Action of the Sun ſhould be hinder'd for a long Time, chiefly then when the Cauſes of the Froſt concur.*

Having aſſigned his Cauſes, he applies them to his five Periods, and the more remarkable Accidents that happen'd in them.

But after all, there are ſome other more hidden extraordinary Cauſes, that he hath not reach'd. For we have all his Cauſes very commonly concurring in other Winters, without the ſame Effects as in the laſt. This preſent, next ſucceeding Winter $17\frac{09}{10}$, we have had (beſides what is common to all Winters, the Obliquity of the Sun's Rays, *&c.*) the Winds as much Northerly and Eaſterly, and as ſtrong; and as much dark Weather; and all concurring too together, as happen'd during the Great Froſt: And yet no more than ordinary ſevere Weather.

But as to miſty, cloudy, dark Weather, which he reckons among his principal Cauſes, I am ſo far from thinking it a Cauſe, that I rather take it to be the Reaſon we have not more frequent ſevere Froſts, at leaſt in our Iſland Places, ſurrounded by the warm Vapours of the Sea. Clouds and Vapours do indeed intercept, and keep off the Sunbeams; and probably imbibe and retain a great deal of Warmth themſelves; nay, perhaps they may (as he ſaith) reflect back ſome of the Sun-rays: But we conſtantly in Winter find, that the fewer the Exhalations are, and the clearer the Air, and after the Warmth of the Sun by Day, the ſharper the Froſt is at Night.

I do not pretend to aſſign Cauſes; yet thus much ſeems to me reaſonable: That the great Mint of Meteors being the ſuperior Regions of the Air, and the Source of Exhalations being the Terraqueous-Globe, in thoſe two Places we are to ſeek for the farther, and more grand Cauſes of the late Froſt. And in the fourteen and more Years Obſervations I have made of the Weather, *&c.* I have found a great deal to be attributed to the Increaſes and Decreaſes of the Cold of the upper Regions, as alſo to the inner Diſpoſitions of our Globe, at leaſt to the greater or leſs Plenty of Vapours and Exhalations. But not as yet having Obſervations enough to clear and demonſtrate my Hypotheſis, I ſhall defer what I might have ſaid.

Effects of Thunder and Lightning *in* Ireland, *communicated by* S. Molyneux, *Eſq;* n. 313. p. 36.

XVIII. 1.) Strange were the Effects of the Thunder and Lightning which happen'd at Mrs. *Cloſe*'s Houſe at *New-Forge* in the County of *Down* in *Ireland*, on the *9th* of *Aug.* 1707. I waited on her about a Fortnight after to inform myſelf of the Particulars. She told, that the whole Day was cloſe, hot, and ſultry, little or no Wind ſtirring till towards the Evening; that there was a ſmall Breeze with ſome miſling Rain, which laſted about an Hour; that as the Air darken'd after Sun-ſet, ſhe ſaw ſeveral faint Flaſhes of Lightning, and heard ſome Thunder-claps, as at a Diſtance; that between 10 and 11 of the Clock, both were very violent and terrible, and ſo increaſed and came on more frequent till a little before 12 of the Clock; that one Flaſh of Lightning, and one Clap of Thunder came both at the ſame Time louder and more dreadful than all the reſt, which, as ſhe thought, ſhook and inflam'd the whole Houſe; and being ſenſible at that Inſtant of a violent ſtrong ſulphureous Smell in her Chamber, which ſhe did not perceive before, and feeling a thick groſs Duſt falling on her Hands and Face as ſhe lay in Bed, ſhe concluded that Part of her Houſe was thrown down by the Thunder, or ſet on Fire by the Lightning; that ariſing, and calling for Candles, ſhe found her Bed-Chamber full of Smoak and Duſt, as alſo the Kitchen that was beneath it: The reſt of the Houſe being ſafe, ſhe only obſerv'd the Looking-glaſs, that hung in her Chamber to be broken.

The next Day ſhe found, upon further Search and Enquiry, that Part of the Top or Corniſh of the Chimney, which ſtood without that Gable-end of the Houſe where her Chamber was, was ſtruck off; that Part of the Copeing of the Splay of the Gable-end itſelf was broken down, and the Shingles on the Roof adjoining thereto (to the Number of 12 or 16) were raiſed or ruffled, but none ſhatter'd or carry'd away; that Part of the Ceiling in her Chamber beneath thoſe Shingles was forc'd down, and Part of the Plaiſter and Pinning-ſtones of the adjoining Wall, was alſo broken off and looſen'd, (the whole Breach 16 or 20 Inches abroad.) That at this Place there was left on the Wall a ſmutted Scar or Trace, as if made black by the Smoak of a Candle, which was directed downwards towards another Place on the ſame Wall whereon a Breach was alſo made as the former, and of the ſame Dimenſions, Part of which was behind the Place where the Looking-glaſs did hang; that the Boards on the Back of a large Hair-Trunk full of Table and other Linnen, ſtanding beneath the Looking-glaſs, were forc'd in, and ſplinter'd as if by the Blow of a Smith's Sledge; that two Parts of three of the Linnen within this Trunk were pierced or cut through, the Cut appearing of a Quadrangular Figure, and between two or three Inches over; that the End of the Trunk was likewiſe forc'd out, as the Back was drove in; that at about two Feet diſtance from the End of this Trunk (where the Floor and the Side-Wall of the Houſe joined) there was a ſmall Breach made in the Plaiſter, where a ſmall Chink or Crevice was to be ſeen between the ſide Board of the Floor and the Wall, ſo wide as that a Man could thruſt his Fingers down; and that juſt beneath this again, in the Kitchen, the Cieling was forced down, and ſome of the Lime or Plaiſter of the Wall broke off; that exactly under this again, ſtood a large Tub or Veſſel of Wood incloſed with a Crib made of Brick and Lime, which was broke and ſplinter'd all to Pieces, and moſt of the Brick and Lime-Work about it forc'd and ſcatter'd about the Kitchen.

I went from Place to Place, viewing each Particular; and as I found all was done on or near the Gable-end of the Houſe, I have endeavoured to explain it by a Draught, wherein the ſeveral Breaches are diſtinguiſh'd: And as I conceiv'd all to be effected by ſome irreſiſtible Body, I have alſo by two Parallel Lines traced out its irregular Motion. Fig. 21.

The Looking-glaſs was broke with that Violence, that there was not a Piece of it to be found of the Largeneſs of Half-a-Crown: Several Pieces of it were ſticking like Hail-ſhot in the Chamber-Door (being of Oak) and on the other Side of the Room; ſeveral of the Edges and Corners of ſome of the Pieces of the broken Glaſs were tinged of a light Flame Colour, as if heated in the Fire; the Curtains of the Bed were cut in ſeveral Pieces, thought to be done by the Pieces of the Glaſs; ſeveral Pieces of Muſlin and wearing Linnen, left on a Trunk, were thrown and ſcatter'd about the Room, no way ſinged or ſcorched; and yet the Hair on the Back of the Trunk, where the Breach was made, was ſinged; the uppermoſt Part of the Linnen within the Trunk was ſafe and well, and the lowermoſt Parcel, conſiſting of 350 odd Ply of Linnen, pierced through, of which, none was any way ſmutted, but the uppermoſt Ply of a Table-cloth that lay above all the reſt. She told me, there was a yellow Singe or Stain perceivable on ſome Part of the other Linnen ſo damag'd the next Day; and the whole Linnen ſmell'd ſtrong of Sulphur; but neither this yellow Stain or Smell was perceivable when I was there: That the Glaſs of two Windows in the Bed-Chamber above, and two Windows in the Kitchen beneath, was ſo ſhatter'd, that there was ſcarce one whole Pane left in any of them; that the Pewter, Braſs, and Iron Furniture in the Kitchen were thrown down, and ſcatter'd about the Kitchen, particularly a large Girdle about 20 Pounds Weight, that hung upon an Iron Hook near the Cieling, was found lying on the Floor: That a Cat was found dead the next Morning in the Kitchen, with its Legs extended as in a going Poſture, in the Middle of the Floor, with no other Sign of being hurt, than that the Furr was ſinged a little, about the ſetting on of the Tail.

She told me too, that about ſome few Days before this Accident happen'd, ſhe remov'd a Table Preſs-Bed from the Place where the Hair-Trunk ſtood, wherein two little Girls (her Daughters) uſed to lie; which ſhe look'd upon as a particular Piece of Providence.

The Wall both above and below a little Window in the ſame Gable-end, was ſo ſhatter'd at the ſame Time, that the Light could be ſeen through the Crevices in the Wall; and that upon a large Stone on the outſide of the Wall beneath this Window, was to be ſeen a Mark, as if made by the Stroke of a Smith's Sledge, or large Iron Crow, with which a Splinter or Piece of the Stone was broken off of ſome Pounds Weight. I was further informed, that from the Time of that great Thunder-clap, both the Thunder and Lightning diminiſh'd gradually, ſo that in an Hour's Time all was ſtill and quiet again.

— at Ipſwich *by Mr.* O. Bridgman, n. 316. p. 317.

2.] There happen'd at *Ipſwich* on the 16*th* of *July* 1708, a moſt violent Storm of Thunder and Lightning; it began about Six to be perceiv'd at ſome Diſtance, and aroſe in the South-Weſt. I was then on the higheſt Eminence about this Town, whence I could plainly diſtinguiſh the working of the Storm: The Inſtant I perceiv'd the Flaſh (which I judg'd to be about four Miles diſtant) it ſeem'd to extend itſelf like a Bow, and caſt its Light a conſiderable Way round it, and the Shaft of Lightning (if I may ſo call it) did not run in a waving angular Figure, as uſual, but in a ſtraight Shaft of Fire, like the Fuze of a Bomb, directly from the Cloud to the Ground; upon which, and finding the Storm approach, I haſten'd Home; and ſoon after, we had two or three prodigious Flaſhes of Lightning, and the Noiſe of the Thunder that ſucceeded them was ſo great, and cauſed ſuch an Emotion in the Air, that it made the Rooms ſhake, and the Windows rattle, as in a great Storm of Wind. Dr. *Dade* aſſur'd me, that at that Time the Lightning ſeem'd to dwell ſome conſiderable Space on the Ground, and that he could very plainly feel the Heat of it in his Face. The Paſſage-Boat was at that Time coming from *Harwich*, and juſt got to the Town, when a terrible Flaſh came, which kill'd the Maſter, and three more Perſons that were on Board. I ſaw one of them the next Day; he had a Wound in his Thigh, his Breaſt was lacerated, as if he had been whipp'd with Wires, and his Face and Body as black, as if he had been blown up with Gunpowder, and Thouſands of ſmall black Spots about him. The Maſter of the Veſſel was not at all disfigur'd, had only one Wound on his Side, like a freſh Burn, no other Mark about him; the Chain of his Watch was melted, yet no Burn could be perceiv'd on his Breeches or Cloaths. The third Perſon was very much torn and ſhatter'd ter'd about the Head, the Crown of his Hat was taken clear out, as if it had been cut out, and ſeveral Parcels of his Hair drove into the Subſtance of the Hat. The fourth was very little disfigur'd, only a black Spot on his Side, and a ſmall Wound, as if made with a cauterizing Iron. There were ſeveral others a-board wounded and ſtunn'd. One *Artis* had his Hair burnt cloſe to his Head behind, and his Peruke untouch'd: He had a Scratch on his Arm about four Inches long, and a ſmall Hurt below the Elbow; he fell that Night into a violent Fever, grew delirious, and is pronounc'd irrecoverable. Whether he receiv'd any Hurt on his Brain, or the Violence of the Fever cauſes the Delirium, remains undetermin'd. There was no Mark to be ſeen on his Coat, Waſtecoat, or Shirt, where he had his Hurt on his Arm. Two of the Perſons kill'd, were on the outſide, and the other two under the Tilt of the Boat; and what is pretty remarkable, the two that were within the Tilt, ſate on each Hand of a Woman, that receiv'd no Damage. One Perſon had the Soal of his Shoe unripp'd from the Leather, and no other Damage. I wonder the Blaſt lighting ſo directly on the Boat, did not ſhatter it all to Pieces: There was another Boat that follow'd them, and receiv'd no Damage, and took out the reſt of the poor frighted Wretches; the Maſter of which does affirm, he ſaw the Fire light on the Bow-ſprit of the former Boat, where meeting a ſmall Reſiſtance, it flew into ſmall Streams like a Rocket, part into the Boat, part into the Water; which, if true, no doubt, was the Cauſe of the Miſchief being done in ſo many different Parts of the Boat; and does in ſome Meaſure ſolve the ſeeming Difficulty of the Woman's being unhurt between the two Perſons that were kill'd.

— *at* Colcheſter *on the* ſame Day, *by* *Mr.* J. Nelſon; *ibid.*

3.] At *Colcheſter*, on *July* 16, 1708. about Eight of the Clock at Night, (the greater Part of the Afternoon being cloudy, but more thick toward Night, with Thunder at a Diſtance for above an Hour before, and much Lightning) I hard a Thunder-Crack ſo loud, as if it were cloſe to me, (the like I never heard before;) at which Time the Thunder and Lightning broke into Mr. *King*'s Houſe, beginning at the South-ſide thereof, at the Gable-end, breaking ſeveral Roof-Tiles, and near 20 other, as at *c* in the *Figure*, continuing its Courſe perpendicular, and in a ſtraight Line (the only Motion that ſeems conſiſtent with ſuch Violence, which, it ſeems, was otherwiſe in the Gentlewoman's Houſe in *Ireland*) it went into a Lean-to, and lighting on a bunching out of the Wall at *d*, it enter'd into the Strong-Beer Buttery through the Laths, and forc'd a Cork out of the lower Tap-hole of a But: In its Way at *a*, it ſhiver'd a Stud about three Inches ſquare, ſo that one Side remain'd nail'd to Laths, yet not much thicker than a Lath, and alſo brake it in two, as if it were a Tobacco-pipe. Below the Beam at *b*, it

Fig. 20.

clave or ſplit a Stud, about four Inches ſquare, ſeveral Feet down; which is there ſtanding; this was from its violent razing on the outſide. At the Time of this Blow, Mr. *King* was in the Lean-to, but receiv'd no Hurt; he ſmell'd a ſtrong ſulphureous Scent. It caſt the broken Wall divers Rood with the Violence. There was ſome little Damage done to *Alhallows* Church about the ſame Time in the ſaid Town.

Divers Boats were carrying Perſons from *Harwich* to *Ipſwich* on the *Orwell*; the Violence of the Thunder and Lightning kill'd four dead immediately, made a Lad run mad, and wounded the reſt that were in that Boat, which were twelve Perſons, and melted a Watch and the Chain all of a Lump which was in a dead Man's Pocket; this was about the ſame Time of the aforemention'd. Mr. *Thomas Holborow* of *Colcheſter* was Eye-witneſs to this: Being in one of the Boats, he ſmell'd ſuch a Scent of Sulphur, as he could not bear. This was about 18 Miles N. E. of *Colcheſter*, and one Mile S. E. it was no more violent than an ordinary Storm.

——*in* York-ſhire, *with violent* Rain; *by Mr.* R. Thoreſby. n. 319. p. 289.

4.] On the 5*th* Day of *July* 1708, we had *a Storm of Thunder, Lightning, and violent Rain*; I was then at the *Spaw* at *Harrow-gate*, near *Knaresborough*; where having a ſpacious View upon the open Foreſt, I obſerv'd the Motion of the Clouds and Storm, which began in the Weſt, and wheel'd about by the North and Eaſt to the South. When the Night drew on, the Lightning appear'd more dreadful. The Intermiſſion between the Flaſhes was very ſmall; the Claps of Thunder were very loud, and the Flaſhes of Lightning were continu'd. The Reverend Mr. *Furnis* of *Bewerly* writes, that *Thomas Horner*, with others, flying from the Violence of the Rain, which ſeem'd rather to fall in *Spouts* than Drops, took ſhelter in a neighbouring Barn, whence, after ſeveral frightful Thunder-claps, they were expell'd by the *Bolt*, as they term'd it, but really the Lightning, which ſinged the Hair of the ſaid *Horner*, blew another Man backward, who was climbing up the Hay-Mow, left a ſulphureous Stench behind it, and burnt the Barn and Hay. The *Inundation* of Rain was ſurprizing; it tore up much of the Road and Street, from the Church to the Bridge, and made Pits in ſome Places, ſeveral Yards deep, threw down Part of a Barn and a Stable, both of them lately built; it puſh'd into moſt of the Houſes in the Town; the Water, in ſome, was as high as the Soals of the Windows, and block'd up the Door of one Houſe with Gravel, almoſt to the very Top. Several Perſons were in great Danger, but only one Woman drown'd: She was hurry'd away with the Violence of the Stream, and not found till the fourth Day after. It removed the Bole of a large Oak ſeveral Yards; bore down the moſt Part of four Wood Bridges, and has left at the End of the great Stone Bridge, or within about 100 Yards of it, as much Gravel, &c. as is computed at above a thouſand Cart Loads. For all this Deluge, the River *Nidd* kept within Bounds.

5.] We had much Thunder and Lightning in *Yorkſhire*, on the 12th of *December* 1710, in the Morning. The Lightning was ſo ſevere, that one *Sainor* a Gardener, as he was riding over *Bramham-moor*, thought his Hair had been burnt, and his Face ſcorch'd at one Flaſh, which being more ſevere than the reſt, did actually ſet on Fire the Stick he had in his Hand, as he was ready to depoſe upon Oath before the Mayor of *Leeds*, who preſented me with the ſaid Hazle Rod, which the Gardener had given him. It yet retains Part of the Blackneſs, tho' the Man (little minding it as a Curioſity) had beat off much of the End of the Rod in forcing his Horſe forward.

—*in* Yorkſhire, *by the* ſame. n. 331. p. 321.

6.] At *Sampford Courtney* in *Devonſhire*, on the 7th of *October* 1711, in the Afternoon, when the Miniſter was officiating, (from whom I have this Account) there was ſo great a Darkneſs, that he could hardly ſee with Spectacles: As ſoon as Prayers were over, ſome Men went to ringing, and ſeveral others were talking in the Church-Porch; a great Fire-Ball, on a ſudden, fell in between them, and threw ſome one way, ſome another, but no one received any Hurt: The Ringers ſaid they never knew the Bells go ſo heavy, and were forc'd to leave off: And being very weary, and looking out of the Belfrey into the Church, ſaw four Fire-Balls a little bigger than a Man's Fiſt, which of a ſudden broke to Pieces, ſo that the Church was full of Fire and Smoak.

John Goodman's Man receiv'd a full Blow in the Neck, which made him bleed both at the Noſe and Mouth; but he is very well now. He ſays, that the Fire and Smoak went up into the Tower, which broke a great Beam on which one of the Bells hung, which fell down on the Floor. It likewiſe carried away one of the Pinnacles of the Tower next the Town, and threw ſome of the Stones near a Barn Door at a pretty Diſtance from the Church, and has done ſome Damage to the Barn at one End. The Chimney of the Houſe was remov'd in ſuch a manner, by the Thunder and Lightning, that all People admir'd that it ſtood, and did not fall upon the Houſe. Tho' the People ran about in great Conſternation, no one was hurt.

—*in* Devonſhire, *communicated by Mr.* J. Chamberlayne. n. 336. p. 528.

XIX. I have collected what I can remember, relating to a *Meteor* I ſaw in *Jamaica* about the Year 1700. As I was riding one Morning from my Habitation, ſituated about three Miles North-Weſt from *St. Jago de la Vega*, I ſaw a Ball of Fire, appearing to me of the Bigneſs of a Bomb, ſwiftly falling down with a great Blaze.

A Fiery Meteor, *&c in* Jamaica, *by Mr.* H. Barham. n. 357. p. 837.

Blaze. As I thought it fell into the Town; but when I came within a Quarter of a Mile of the Town, I ſaw many People gather'd together a little to the Southern in the *Savanna*, to whom I rode up, where they were admiring at the Ground's being ſtrangely broke and plough'd in by a Ball of Fire, which, as they ſaid, fell down there. I obſerv'd there were many Holes in the Ground, one in the middle of the Bigneſs of a Man's Skull, and five or ſix ſmaller Holes round about it, of the Bigneſs of a Man's Fiſt, and ſo deep (eſpecially the biggeſt) as not to be fathom'd by what long Switches or Sticks they had at Hand. I did not hear that any was ſo curious as to make any farther Search: It was obſerv'd, that the green Graſs was perfectly burnt near the Holes, and a ſtrong Smell of Sulphur remain'd thereabouts for a good while after.

Note, that we had a terrible rainy Night before, with much Lightning and great Thunder-Claps, which we have very frequently in *Jamaica*, often killing Cattle in the Fields. Mr. *Henry Lord*, who lives at *Dry-River*, had two Sons ſtruck dead with Lightning, in 1716, without any Wounds or Appearance of Hurt found about them. And as theſe Claps are much louder and ſtronger than any I ever heard in *Europe*, ſo are our Showers of Rain, pouring down in a moſt violent manner. We have Lightning all the Year round, but our great Rains are in the Months of *May*, *Auguſt*, and *October*. I knew *May* for two or three Years without Rain, which was look'd upon as a great Wonder: And we paid dear for it in our *Indigo:* For a Caterpillar appear'd and wove a fine Silk about the *Indigo-Plant*, and deſtroy'd it all, hurting nothing elſe. *May*-Rains uſed to deſtroy theſe Worms. *Auguſt* and *October* never go out without a Flood, we having then univerſal Rains all over the Iſland, coming from the Sea: For we have often Rains in the Mountains from the Clouds lodging there, when we have none in the Low-lands.

Our Iſland is full of Mines, and, if ſearch'd into, I queſtion not but very rich. We are very ſubject to Earthquakes, ſeveral happening every Year, eſpecially after great Rains, which fill up all our great Cracks in the Surface of the Earth: For in a very dry Time, we have them ſo very large, deep, and gaping ſo open and wide, that it is dangerous to ride over ſome Parts of the *Savannaes*, for fear a Horſe ſhould get his Legs into them. Our Earthquakes make a Noiſe or Rumbling in the Earth, before we feel the Shake; and ſeem to run ſwiftly to the Weſtward.

A Lunar Rain-Bow *ſeen in* Derbyſhire, *by —, communicated by Mr.* R. Thoreſby. n. 331 p. 320.

XX. A Gentleman of great Veracity told me, he had ſeen a *Lunar Rain-Bow* in *Derbyſhire* on *Chriſtmas* 1710. That walking towards *Patterton Green*, about eight in the Evening, he obſerved with great Satisfaction the Bow, which the Moon had fix'd in the Clouds: She had then paſs'd her Full about 24 Hours, the Evening had been rainy, but the Clouds were diſpers'd, and the Moon ſhin'd pretty clear. This *Iris* was more remarkable than that which Dr. *Plot* obſerved at *Oxford*, the 23*d* of *November* 1675, that being only of a white Colour, but this had all the Colours of the *Iris Solaris*, exceeding pleaſant, diſtinct, and grateful to look upon; only faint, comparatively to thoſe we ſee in the Day; as muſt neceſſarily follow, both from the different Beams that cauſe it, and the Diſpoſition of the Medium. What puzzled him the moſt was the Largeneſs of the Arc, which was not ſo much leſs than that of the Sun, as the different Dimenſions of their Bodies, and their reſpective Diſtances from the Earth, ſeem to require: But as to its Entireneſs, and Beauty of its Colours, it was admirable and ſurprizing. It continu'd about ten Minutes, before the Interpoſition of a Cloud hinder'd his further Obſervation.

A Glade *of* Light *ſeen in the* Heavens, *by Mr.* W. Derham, n. 305. p. 2220.

Fig. 21.

XXI. As I was obſerving the Immerſions of the third and fourth Satellite of *Saturn* on the 20*th* of *March* 170$\frac{5}{6}$, in the Evening; I eſpy'd a very odd ſort of Light in the Conſtellation of *Taurus*, the lower End of which was below the Bull's Eye, and the other a good Way above it, and that Star about the middle of the lower End thereof (as in *Fig.* 21.) which repreſents its Appearance to me. This Glade of Light had the ſame Motion that the Heavens had, and was much like the Tail of a Comet, but pointed at the upper End. This Light, I doubt not, is ſuch as Dr. *Childrey* firſt obſerved in *England*; and *Caſſini*, and others afterwards in *France*.

A Pyramidal Appearance *in the* Heavens *ſeen in* Eſſex, *by Mr.* W. Derham. n. 310. p. 2411.

Fig. 22.

XXII. On *Thurſday*, *April* 3, 1707, I perceived in the Weſtern Part of the Heavens, about a Quarter of an Hour after Sun-ſet, a long ſlender *Pyramidal Appearance*, perpendicular to the Horizon. The *Baſe* of this *Pyramid*, I judged to be the Sun (then below the Horizon.) Its *Apex* reach'd 15 or 20 Degrees above the Horizon. It was throughout of a ruſty red Colour; and when I firſt ſaw it, pretty vivid and ſtrong; but the Top-part fainter much than the Bottom, nearer the Horizon. At what time this Appearance began, whether at, or how ſoon after Sun-ſet, I cannot ſay. But about a Quarter of an Hour after Sun-ſet I perceived it, and had, for ſome time, a fair Proſpect of it, the Horizon being pretty free and open where I then was. But after a while, it grew by Degrees weaker and weaker, ſo that in about a Quarter of an Hour after I firſt ſaw it, the Top-part *(a. b. d.)* was ſcarce viſible. But the Lower-part remain'd vivid much longer; but yet grew by Degrees ſhorter and ſhorter. I ſaw the Remains of the lower half (*b. d. e. f.*) a full Hour after Sun-ſet; and ſhould perhaps have ſeen it longer, had the Horizon been open. But it was often in my Walk pent up with Trees.

The whole Atmoſphere ſeem'd hazy, and full of Vapours, eſpecially towards the Sun-ſet. The Moon and Stars were that Evening bearded at that Time, and ſucceeded with an *Halo* about the Moon afterwards. Which Diſpoſition of the Air was probably the Cauſe of the Phænomenon. But the Pyramid was undoubtedly imprinted upon the far diſtant Vapours of the Atmoſphere; it being manifeſtly farther off, or lying beyond ſome ſmall thin Clouds (*C. L. c. l.*) that intercepted it, and in thoſe Parts cover'd and hid it.

I do not remember I ever ſaw any Thing like it, except the white Pyramidal Glade, which is now entituled by the Name of the *Aurora Borealis*; that being (except in Colour and Length) like it.

I have ſearched every Night ſince for this *Pyramis Veſpertina*, but have not ſeen any ſuch Appearance, altho' the next Evening was hazy and likely. I alſo look'd out to ſee whether the *Aurora Borealis* would ſucceed in the Room thereof, but diſcover'd no ſuch Thing.

A Meteor *in* Yorkſhire, *by Mr*. R. Thoreſby. n. 331. p. 322.

XXIII. A ſtrange Meteor was ſeen at *Leeds* 1710, on *Holy Thurſday*; the common People call'd it a Flaming Sword. It was ſeen not only in the Neighbouring Towns, but a great Way North, as alſo above fifty Miles South of *Leeds*. It appear'd here at a Quarter paſt ten at Night, and took its Courſe from South to North: It was broad at one End, and ſmall at the other; and was by ſome thought to reſemble a Trumpet, and mov'd with the broad End foremoſt: the Light was ſo bright, that People ſaw their own Shadows. I was reading (the Curtain of the Window being drawn) ſo ſaw nothing, except a ſudden Flaſh of Light. It is remarkable, that all Perſons (tho' at many Miles Diſtance from each other, when they ſaw it) thought it fell within three or four Furlongs of them, and that it went out with bright Sparklings at the ſmall End. An ingenious Clergyman told me, that it was the ſtrangeſt *Deceptio viſus* he was ever ſenſible of, if it was not abſolutely extinguiſh'd within a few Paces of him; and yet others ſaw it many Miles off, further North in a few Moments.

It has been ſeen in the Counties of *Nottingham* and *Derby*, as well as *York* and *Lancaſter*.

A ſtrange Meteor, *or* Aurora Borealis *ſeen in* Ireland, *by Mr*. Neve. n. 320. p. 310.

XXIV. 1.) On *Sunday*, *November* 16, 1707, after a froſty Morning, and fair ſtill Day, Wind North-Weſterly, about half an

Hour after eight in the Evening, there appear'd a very ſtrange Light in the North. The Evening was clear and Star-light, only the Horizon was darken'd with condenſed Vapours in the North, reaching, as I gueſs, ten or fifteen Degrees above the Horizon. Out of this Cloud proceeded ſeveral *Streams* or *Rays* of *Light*, like the Tails of ſome Comets, broad below, and ending in Points above. Some of them extended almoſt to the Tail of *Urſa Minor*, and all were nearly perpendicular to the Horizon, and it was as bright, as if the Full Moon had been riſing in the Cloud. But what I wonder'd at moſt, was, the Motion of the dark and lighter Parts running ſtrangely through one another in a Moment; ſometimes to the Eaſt, and ſometimes to the Weſt. It continued, after I firſt ſaw it, about a Quarter of an Hour, often changing its Face and Appearance, as to Form and Light; ſometimes broken, ſometimes entire and long Rays of Light in the clear Sky, quite ſeparate from and above the Cloud, and none below in the Cloud.

2.] Much ſuch another Appearance Mr. *Barret* was credibly inform'd was ſeen in his Neighbourhood in *Eſſex*, in *September* or *October* 1706.

— *by Mr.* W. Derham. *ib.*

XXV. The *Theory* of the Air ſeems to be perfectly well underſtood, and the differing Denſities thereof at all Altitudes, both by Reaſon and Experiment, are ſufficiently defined: For ſuppoſing the ſame Air to occupy Spaces reciprocally proportional to the Quantity of the ſuperior or incumbent Air, I have (*) elſewhere prov'd, that at 40 Miles high, the Air is rarer than at the Surface of the Earth, about 3000 Times; and that the utmoſt Height of the Atmoſphere, which reflects Light in the *Crepuſculum*, is not fully 45 Miles: Notwithſtanding which, it is manifeſt that ſome Sort of Vapours, and thoſe in no ſmall Quantity, ariſe nearly to that Height. An Inſtance of this may be given in the great Light, (†) *September* 1676, mention'd by Dr. *Wallis*, which was ſeen in very diſtant Counties, almoſt over all the South Part of *England*. Of which, though the Doctor could not get ſo particular a Relation, as was requiſite to determine the Height thereof, yet from the diſtant Places it was ſeen in, it could not but be very many Miles high.

An Account *of ſeveral extraordinary* Meteors; *by* *Dr.* E. Halley. n.341. p.159.

(*) *Vid.* Supra, V. II. C. I. S. IX.

(†) *Vid.* Supra, V. II. C. I. S. LXXI.

So likewiſe that Meteor which was ſeen in 1708, on the *31ſt* of *July*, between nine and ten a-Clock at Night, was evidently between 40 and 50 Miles perpendicularly high, and as near as I can gather, over *Sheerneſs* and the *Buoy on the Nore.* For it was ſeen at *London* moving horizontally from E. by N. to E. by S. at leaſt 50 Degrees high; and at *Redgrave* in *Suffolk*, on the *Yarmouth* Road, about 20 Miles from the Eaſt Coaſt of *England*, and at leaſt 40 Miles to the Eaſtward of *London*, it appear'd a little to the Weſtward of the

South, ſuppoſe S. by W. and was ſeen about 30 Degrees high, ſliding obliquely downwards. We may conclude, that it was not many Miles more Weſterly than *Redgrave*, which is above 40 Miles more Eaſterly than *London.* Suppoſe it, therefore, where perpendicular, to have been 35 Miles Eaſt from *London*, and by the Altitude it appear'd at in *London, viz.* 50 Degrees, its Tangent will be 42 Miles; for the Height of the Meteor above the Surface of the Earth, which alſo is rather of the leaſt, becauſe the Altitude of the Place ſhewn me, is rather more than leſs than 50 Degrees: And the ſame may be concluded from the Altitude it appear'd in at *Redgrave*, near 70 Miles diſtant. Though at this great Diſtance it appear'd to move with an incredible Velocity, darting, in a very few Seconds of Time, for about 12 Degrees of a great Circle from North to South, being very bright at its firſt Appearance; and it died away at the End of its Courſe, leaving for ſome Time a pale Whiteneſs in the Place, with ſome Remains of it in the Track where it had gone; but no hiſſing Sound as it paſs'd, or Bounce of an Exploſion, were heard.

It may deſerve Enquiry, how ſo great a Quantity of Vapour ſhould be raiſed to the very Top of the Atmoſphere, and there collected, ſo as upon its Accenſion, or otherwiſe Illumination, to give a Light to a Circle of above 100 Miles Diameter, not much inferior to the Light of the Moon. 'Tis hard to conceive what ſort of Exhalations ſhould riſe from the Earth, either by the Action of the Sun, or ſubterranean Heat, ſo as to ſurmount the extreme Cold and Rareneſs of the Air in thoſe upper Regions.

Like to this, but much more conſiderable, was that famous Meteor which was ſeen to paſs over *Italy* on the 21*ſt* of *March O. S. Anno* 1676, about an Hour and three Quarters after Sun-ſet, which happen'd to be obſerv'd by the famous Profeſſor of Mathematicks in *Bononia Geminian Montanari*, as may be ſeen in his *Italian* Treatiſe. He obſerves that at *Bononia*, its greateſt Altitude in the S. S. E. was 38 Degrees, and at *Sienna* 58 to the N. N. W. that its Courſe by the Concurrence of all the Obſervers, was from E. N. E. to W. S. W. that it came over the *Adriatick* Sea, as from *Dalmatia*: That it croſs'd over all *Italy*, being nearly vertical to *Rimini* and *Savigniano* on the one Side, and to *Legborn* on the other: That its perpendialar Altitude was at leaſt 38 Miles: That in all Places near this Courſe, it was heard to make a hiſſing Noiſe, *To make a Noiſe like a Sky-rocket, to biſs through the Air like a Train of Gun-powder:* That having paſs'd over *Legborn*, it went off to Sea towards *Corſica*: And laſtly, that at *Legborn*, it was heard to give a very great Blow, *It thunder'd with a greater Report than that of a large Cannon:* Immediately after which, another ſort of Sound was heard, like the rattling of a great Cart running over Stones, which continued about the Time of a *Credo*.

He concludes, from the apparent Velocity it went on with at *Bononia*, at above 50 Miles Diſtance, that it could not be leſs ſwift than 160 Miles in a Minute of Time. To this he adds the Magnitude thereof, which appear'd at *Bononia* bigger than the Moon in one Diameter, and above half as big again in the other; which with the given Diſtance of the Eye, makes its real leſſer Diameter above half a Mile, and the other in Proportion. This ſuppoſed, it cannot be wonder'd that ſo great a Body moving with ſuch an incredible Velocity through the Air, though ſo much rarified as it is in its upper Regions, ſhould occaſion ſo great a hiſſing Noiſe, as to be heard at ſuch a Diſtance as this was. But 'twill be much harder to conceive, how ſuch an *Impetus* could be impreſs'd on the Body thereof, which by many Degrees exceeds that of any Cannon Ball; and how this *Impetus* ſhould be determined in a Direction ſo nearly parallel to the Horizon, and what ſort of Subſtance it muſt be that could be ſo impell'd and ignited at the ſame Time: There being no *Vulcano*, or other *Spiraculum* of ſubterraneous Fire in the N. E. Parts of the World, that we ever yet heard of, from whence it might be projected.

I have conſider'd this Appearance, and think it one of the hardeſt Things to account for, that I have met with in the *Phænomena* of *Meteors*, and am induced to think, that it muſt be ſome Collection of Matter form'd in the *Æther*, as it were by ſome fortuitous Concourſe of Atoms, and that the Earth met with it as it paſs'd along in its Orb, then but newly form'd, and before it had conceived any great *Impetus* of Deſcent towards the Sun. For the Direction of it was exactly contrary to that of the Earth, which made an Angle with the Meridian at that Time (the Sun being in about 11 Degrees of *Aries*) of 67 Gr. that is, its Courſe was from W. S. W. to E. N. E. wherefore the *Meteor* ſeem'd to be moved the contrary Way: And beſides falling into the Power of the Earth's Gravity, and loſing its Motion from the Oppoſition of the *Medium*, it ſeems that it deſcended towards the Earth, and was extinguiſh'd in the *Tyrrhene Sea*, to the W. S. W. of *Leghorn*. The great Blow being heard upon its firſt Immerſion into the Water, and the rattling, like the driving a Cart over Stones, being what ſucceeded upon its quenching; ſomething like which, is always obſerved upon quenching a very hot Iron in Water.

There has fallen into my Hands an Account of much ſuch another Appearance, ſeen in *Germany*, in the Year 1686, at *Leipſick*, by the late Mr. *Gottfreid Kirch*, who, in his Appendix to his *Ephemerides* for the Year 1688, gives us this remarkable Relation in the following Words.

On the ninth Day of July, *O. S. at Half an Hour paſt One in the Morning, there appeared a Ball of Fire with a long Tail, in 8½ Degrees of* Aquary, *and* 4 *Gr. to the North, which continued immoveable for Half a Quarter of an Hour. Its Diameter was nearly equal to the Semidiameter of* *the Moon. At firſt its Light was ſo great, that by it one might read without a Candle. It afterwards vaniſh'd in its Place by degrees. The ſame Phænomenon was alſo ſeen at the ſame Time by others in other Places, particularly at* Schlaize, *a Town* 11 German *Miles diſtant from hence* (Leipſick) *to the South, at the Altitude of about* 60 *Degrees from the Southern Horizon.*

At the Time of this Appearance the Sun was in 26½ Gr. of *Cancer*, and by the given Place of the Meteor, 'tis plain, it was ſeen about ¼ of an Hour paſt the Meridian, or in S. *by* W. and by its Declination it could not be above 24 Degrees high at *Leipſick*, though the ſame, at *Schlaize*, was about 60 Gr. high: The Angle therefore at the Meteor, was about 36 Gr. Whence, by an eaſy *Calculus*, it will be found, that the ſame was not leſs than 16 *German* Miles diſtant in a right Line from *Leipſick*, and above 6¼ ſuch Miles perpendicular above the Horizon, that is, at leaſt 30 *Engliſh* Miles high in the Air. And though he ſays of it, *that it continued immoveable for half a Quarter of an Hour*; 'tis not to be underſtood that it kept its Place like a fix'd Star, all the Time of its Appearance; but that it had no very remarkable progreſſive Motion. For himſelf has at the End of the ſaid *Ephemerides* given a Figure of it, whereby it appears, that it darted downwards obliquely to the Right-hand, and where it ended, left two Globules or Nodes, not viſible but by an Optick Tube.

The ſame Mr. *Kirch*, in the Beginning of a *German* Treatiſe of his, concerning the great Comet which appear'd in the Year 1680, intituled, **Neue himmels zeitung**, printed at *Nuremburg*, *Anno* 1681, gives us a Relation of ſuch another luminous Meteor ſeen likewiſe at *Leipſick*, on the 22*d* of *May*, 1680, *ſt. vet.* about Three in the Morning: Which, though himſelf ſaw not, was obſerved by divers Perſons, who made various Reports of it; but the more intelligent agreed, that it was ſeen deſcending in the North, and left behind it a long white Streak where it had paſs'd. At the ſame Time at *Haarburgh*, the like Appearance was ſeen in N. E. or rather N. N. E. as alſo at *Hamburg*, *Lubeck* and *Stralſund*, all which are about 40 *German* Miles from *Leipſick*: But in all theſe Places, by Perſons unacquainted with the Manner of properly deſcribing Things of this Kind. So that all we can conclude from it is, that this Meteor was exceeding high above the Earth, as well as the former.

All the Circumſtances of theſe *Phænomena* agree with what was ſeen in *England* in 1708.

An Account of Lights *ſeen in the Air*, March 6, 1715-16, *&c. by Dr.* E. Halley n. 347. p. 406.

XXVI. 1.] The *Society* having received Accounts from many Parts of *Great Britain*, of the unuſual *Lights*, which have appeared in the *Heavens*, deſired me to draw up a general Relation of the *Fact*, and to explain more at large ſome Conceptions of mine, which I had propoſed to them, relating to the Cauſe. The Account of this Appearance take as follows.

On *Tueſday* the ſixth of *March*, *ſt. vet.* in the current Year 1716, (the Afternooon having been very ſerene and calm, and ſomewhat warmer than ordinary) about the Time it began to grow dark, (much about ſeven of the Clock) not only in *London*, but in all Parts of *England*, where the Beginning of this wonderful Sight was ſeen; out of what ſeem'd a duſky Cloud, in the N. E. Parts of the Heaven, and ſcarce ten Degrees high, the Edges whereof were tinged with a reddiſh yellow, like as if the Moon had been hid behind it, there aroſe very long luminous Rays or Streaks perpendicular to the Horizon, ſome of which ſeem'd nearly to aſcend to the Zenith. Preſently after, that reddiſh Cloud was ſwiftly propagated along the Northern Horizon into the N. W. and ſtill farther Weſterly; and immediately ſent forth its Rays from all Parts, now here, now there, they obſerving no Rule or Order in their riſing. Many of theſe Rays ſeeming to concur near the Zenith, formed there a *Corona*, or Image, which drew the Attention of all Spectators. Some liken'd it to that Repreſentation of *Glory* wherewith our Painters in Churches ſurround the Holy *Name of God.* Others to thoſe radiating *Stars*, wherewith the Breaſts of the *Knights* of the Order of the *Garter* are adorn'd. Many compar'd it to the *Concave* of the great *Cupola* of St. *Paul*'s Church, diſtinguiſh'd with Streaks alternately light and obſcure, and having in the middle a Space leſs bright than the reſt, reſembling the Lantern. Whilſt others, to expreſs as well the Motion as Figure thereof, would have it to be like the Flame in an Oven, reverberated and rolling againſt the arched Roof thereof: Some thought it liker to that tremulous Light which is caſt againſt a Cieling by the Beams of the Sun, reflected from the Surface of Water in a Baſon that's a little ſhaken; whoſe reciprocal vibrating Motion it very much imitated. But all agree, that this *Spectrum* laſted only a few Minutes, and exhibited itſelf variouſly tinged with Colours, yellow, red, and a duſky green: Nor did it keep in the ſame Place; for when firſt it began, it appear'd a little to the Northwards of the Zenith, but by degrees declining towards the South, the long *Striæ* of Light, which aroſe from all Parts of the Northern Semicircle of the Horizon, ſeem'd to meet together, not much above the Head of *Caſtor*, or the Northern *Twin*, and there ſoon diſappear'd.

After the firſt *Impetus* of this aſcending Vapour was over, the *Corona* appear'd no more; but ſtill, without any Order as to Time, or Place, or Size, luminous *Radii*, like the former, continued to ariſe perpendicularly, now oftener, and again ſeldomer; now here, now there; now longer, now ſhorter. Nor did they proceed as at firſt out of a Cloud, but oftener would emerge at once out of the pure Sky, which was more than ordinary ſerene and ſtill. Nor were they all of the ſame Form. Moſt of them ſeem'd to end in a Point upwards, like erect Cones; others like truncate Cones or Cylinders, ſo much reſembled the long Tails of Comets, that at firſt ſight they might well be taken for ſuch. Some of theſe Rays would continue viſible for ſeveral Minutes; when others, and thoſe the much greater Part, juſt ſhew'd themſelves, and died away. Some ſeem'd to have little Motion, and to ſtand, as it were fix'd, among the Stars, whilſt others, with a very perceptible Tranſlation, mov'd from Eaſt to Weſt under the Pole, contrary to the Motion of the Heavens; by which Means they would ſometimes ſeem to run together, and at other times to fly one another.

After this Sight had continued about an Hour and a half, thoſe Beams began to riſe much fewer in Number, and not near ſo high, and by Degrees that diffuſed Light, which had illuſtrated the Northern Parts of the Hemiſphere, ſeem'd to ſubſide, and ſettling on the Horizon formed the Reſemblance of a very bright *Crepuſculum*: That this was the State of this *Phænomenon*, in the firſt Hours, is abundantly confirm'd by the unanimous Conſent of ſeveral. For, by the Letters we have receiv'd from almoſt all the extreme Parts of the Kingdom, there is found very little Difference in the Deſcription from what appear'd at *London* and *Oxford*; unleſs that in the North of *England* and in *Scotland*, the Light ſeem'd ſomewhat ſtronger and brighter.

Hitherto I have related the Obſervations of others: As to myſelf, I had no Notice of this Matter, till between nine and ten of the Clock; upon the firſt Information of the Thing, I immediately ran to the Windows, which happen'd to regard the South and South-Weſt Quarter; and ſoon perceiv'd, that though the Sky was very clear, yet it was tinged with a ſtrange ſort of Light; ſo that the ſmaller Stars were ſcarce to be ſeen, and much as it is when the Moon of four Days old appears after Twilight. I perceiv'd at the ſame Time a very thin Vapour to paſs before us, which aroſe from the preciſe Eaſt Part of the Horizon, aſcending obliquely, ſo as to leave the Zenith about fifteen or twenty Degrees to the Northward. But the Swiftneſs wherewith it proceeded was ſcarce to be believed, ſeeming not inferior to that of Lightning; and exhibiting, as it paſs'd on, a ſort of momentaneous *Nubecula*, which diſcover'd itſelf by a very diluted and faint Whiteneſs; and was no ſooner formed, but before the Eye could well take it, it was gone, and left no Signs behind it. Nor was this a ſingle Appearance; but for ſeveral Minutes, about ſix or ſeven Times in a Minute, the ſame was again and again repeated; theſe Waves of Vapour regularly ſucceeding one another, and at Intervals very nearly equal; all of them in their Aſcent producing a like tranſient *Nubecula*.

By this Particular we were firſt aſſured; that the Vapour we ſaw, became conſpicuous by its own proper Light, without Help of the Sun's Beams; for theſe *Nubeculæ* did not diſcover themſelves in any other Part of their Paſſage, but only between the *South-Eaſt* and *South*, where being oppoſite to the Sun, they were deepeſt immers'd in the Cone of the Earth's Shadow; nor were they viſible before or after. Whereas the contrary muſt have happen'd, had they borrow'd their Light from the Sun.

I then made all the Haſte I could to a Place where there was a free Proſpect of the Northern Horizon. Being come there, not much paſt ten of the Clock, I found, on the Weſtern Side, *viz.* between W. and N. W. the Repreſentation of a very bright *Twilight*, contiguous to the Horizon; out of which aroſe very long Beams of Light, not exactly erect toward the *Vertex*, but ſomething declining to the South; which aſcending by a quick and undulating Motion to a conſiderable Height, vaniſh'd in a little Time, whilſt others, tho' at uncertain Intervals, ſupply'd their Place. But at the ſame Time, through all the reſt of the Northern Horizon, *viz.* from the North-Weſt to the true Eaſt, there did not appear any Sign of Light to ariſe from, or join to, the Horizon; but what appear'd to be an exceeding black and diſmal Cloud ſeem'd to hang over all that Part of it. Yet was it no Cloud, but only the ſerene Sky more than ordinary pure and limpid, ſo that the bright Stars ſhone clearly in it, and particularly *Cauda Cygni*, then very low in the *North*; the great Blackneſs manifeſtly proceeding from the Neighbourhood of the Light which was collected above it. For the Light had now put on a Form quite different from all that we have been deſcribing, and had faſhion'd itſelf into the Shape of two *Laminæ* or Streaks, lying in a Poſition parallel to the Horizon, whoſe Edges were but ill terminated. They extended themſelves from the *N.* by *E.* to the *North-Eaſt*, and were each about a Degree broad; the undermoſt about eight or nine Degrees high, and the other about four or five Degrees over it; theſe kept their Places for a long Time, and made the Sky ſo light, that I believe a Man might eaſily have read an ordinary Print by the Help thereof.

Whilſt I was viewing this ſurprizing Sight, and expecting what was further to come, the Northern End of the upper *Lamina* by Degrees bent downwards, and at length cloſed with the End of the other that was under it, ſo as to ſhut up on the Northſide an intermediate Space, which ſtill continued open to the Eaſt. Not long after this, in the ſaid included Space, I ſaw a great Number of ſmall Columns or whitiſh Streaks to appear ſuddenly, erect to the Horizon, and reaching from the one *Lamina* to the other; which inſtantly diſappearing, were too quick for the Eye, ſo that I could not judge whether they aroſe from the under, or fell from the upper,

per, but by their ſudden Alterations, they made ſuch an Appearance, as might well enough be taken to reſemble the Conflicts of Men in Battle.

And much about the ſame Time, there began on a ſudden to appear, low under the Pole, and very near due North, three or four lucid *Areas*, like Clouds, diſcovering themſelves, in the pure but very black Sky, by their yellowiſh Light. Theſe, as they broke out at once, ſo after they had continued a few Minutes, diſappear'd as quick as if a Curtain had been drawn over them: Nor were they of any determined Figure, but both in Shape and Size might properly be compar'd to ſmall Clouds illuminated by the full Moon, but brighter.

Not long after this, from above the aforeſaid two *Laminæ*, there aroſe a very great *Pyramidal* Figure, like a *Spear*, ſharp at the Top, whoſe Sides were inclin'd to each other with an Angle of about four or five Degrees, and which ſeem'd to reach up to the *Zenith*, or beyond it. This was carried with an equable, and not very ſlow Motion, from the N. E. where it aroſe, into the N. W. where it diſappear'd, ſtill keeping in a perpendicular Situation, or very near it; and paſſing ſucceſſively over all the Stars of the *Little Bear*, did not efface the ſmaller ones in the Tail, which are but of the fifth Magnitude; ſuch was the extreme Rarity and Perſpicuity of the Matter whereof it conſiſted.

This ſingle Beam was very remarkable for its Height above all thoſe that for a great while before had preceded it, or that follow'd it.

It being now paſt eleven of the Clock, and nothing new offering itſelf to our View, but repeated *Phaſes* of the ſame Spectacle; being returned to my Houſe, I went to my upper Windows, which conveniently enough regarded the N. E. Part of the Heavens, and ſoon found that the two *Laminæ* or Streaks parallel to the Horizon, had now wholly diſappear'd; and the whole Spectacle reduced itſelf to the Reſemblance of a very bright *Crepuſculum* ſettling on the Northern Horizon, ſo as to be brighteſt and higheſt under the Pole itſelf; from whence it ſpread both Ways into the N. E. and N. W. Under this, in the middle thereof, there appear'd a very black Space, as it were the Segment of a leſſer Circle of the Sphere cut off by the Horizon. It ſeem'd to the Eye like a dark Cloud, but was not ſo; for by the Teleſcope the ſmall Stars appear'd through it more clearly than uſual, conſidering how low they were: And upon this as a *Baſis*, our *Lumen Auroriforme* reſted, which was no other than a Segment of a Ring or Zone of the Sphere, intercepted between two Parallel leſſer Circles, cut off likewiſe by the Horizon; or the Segment of a very broad *Iris*, but of one uniform Colour; *viz.* a Flame-Colour inclining to yellow, the Center thereof being about forty Degrees below

low the Horizon. And above this, there were ſeen ſome Rudiments of a much larger Segment, with an Interval of dark Sky between, but this was ſo exceeding faint and uncertain, that I could make no proper Eſtimate thereof.

I attended this Phænomenon till near three in the Morning, and the riſing of the Moon: But for above two Hours together, it had no manner of Change in its Appearance, nor Diminution, nor Increaſe of Light; only ſometimes, for very ſhort Intervals, as if new Fuel had been caſt on a Fire, the Light ſeem'd to undulate and ſparkle, not unlike the riſing of a vaporous Smoke out of a great Blaze, when agitated. But one Thing I aſſured my ſelf of, that this *Iris*-like Figure did by no Means owe its Origin to the Sun's Beams: For that about three in the Morning, the Sun being in the Middle between the North and Eaſt, our *Aurora* had not follow'd him, but ended in that very Point where he then was: Whereas in the true North, which the Sun had long paſs'd, the Light remain'd unchanged, and in its full Luſtre.

Thus I have endeavour'd by Words to repreſent what I ſaw; I have annexed a *Figure* exhibiting that particular Appearance of the two Fig. 23. *Laminæ*, which I ſaw at *London* between the Hours of ten and eleven: Becauſe I do not find, among the many Relations I have ſeen, any one that has taken Notice of it. In this Figure *A B* is the under *Lamina*, ſomewhat broader and brighter than the upper *C D*: It had near its under Edge the *Lucida Lyræ*, and below its Northern Extremity, on the Left-hand, *Cauda Cygni*: And as well above and below theſe, as in the intermediate Space between them, and indeed all round about that Part of the Heavens, the Sky was ſo unuſually dark and black, as if all that *Exotic Light* that had ſhew'd itſelf before, had been then collected into thoſe two Streaks. Only at *Q*, between the Weſt and North-Weſt, and no where elſe, out of a Brightneſs adjoining to the Horizon, there aroſe conical Beams, as *M*, *L*, *N*, after the ſame Manner as at firſt.

Whilſt we ſtood looking on, the Streak *C D*, at its Northern End, bent downward, and joined with the under *A B* at *E*, and included the Space *D C E A B*, which ſtill kept open at the other End towards the Eaſt; and in the mean Time, out of the very clear Sky, ſome luminous Spots, ſituated and figured as in the Scheme at *G*, *G*, *G*, *G*, preſented themſelves to the Eye, in Colour much like the *Laminæ*. Theſe did not ſhew themſelves all together, but came ſucceſſively, yet ſo as two or three of them were ſeen at a Time; and as their coming was inſtantaneous, ſo they went away in a Moment. At the ſame Time likewiſe, the ſeveral little white Columns mark'd *F*, *F*, *F*, *F*, occupied that Part of the Space between the two Streaks next to *E*, and by their ſudden and very irregular Motion, and the vaniſhing of ſome, whilſt others, at the ſame Time, emerged, gave occaſion to the Conception of thoſe that fancied Battles fought in the Air. Laſtly, from about the Middle of *C D*, there aroſe ſuddenly a Cone or Obeliſk of a pale whitiſh Light, greater than any we had yet ſeen, as *H*; which moving from Eaſt to Weſt, with a Motion ſufficiently regular, was tranſlated to *K*, in the North Weſt, and there diſappear'd.

That we might by the ſame Scheme ſhew the Appearance of the laſt Hours, after Midnight; we have made the Light at *Q*, much bigger than what appear'd in the Weſt about ten of the Clock; ſo as to repreſent truly that other. In this Caſe, the Point *Q* muſt, by the Imagination, be ſuppoſed transferr'd to the Interſection of the Horizon and Meridian under the Pole. The Scheme indeed could by no Means be contriv'd to anſwer the wonderful Variety this *Phænomenon* afforded; ſince even the Eye of no one ſingle Obſerver was ſufficient to follow it in the Suddenneſs and Frequency of its Alterations.

Thus I have attempted to deſcribe what was ſeen, and am ſorry I did not ſee the firſt and moſt ſurprizing Part thereof my ſelf: The like is not recorded in the *Engliſh Annals* ſince 1574, that is, above a hundred and forty Years ago, in the Reign of Queen *Elizabeth*. Then, as we are told by the Hiſtorians of thoſe Times, *Cambden* and *Stow*, for two Nights ſucceſſively, *viz.* on the 14*th* and 15*th* of *November* that Year, much the ſame wonderful *Phænomena* were ſeen, with almoſt all the ſame Circumſtances as now.

Nor, indeed, was this then ſo rare a Sight as it has been ſince: For we find, in a Book entituled, *A Deſcription of Meteors*, reprinted at *London* in the Year 1654, whoſe Author writes himſelf *W. F.* D. D. that the ſame Thing, which he there calls *Burning Spears*, was ſeen at *London* on *January* 30, 1560; and again by the Teſtimony of *Stow*, on the 7*th* of *October* 1564. And from foreign Authors we learn, that in the Year 1575, the ſame was twice repeated in *Brabant*, *viz.* on the 13*th* of *February*, and 28*th* of *September*; and ſeen and deſcribed by *Cornelius Gemma*: Who in a Diſcourſe he wrote of the Prodigies of thoſe Times, after ſeveral ill-boding Prognoſticks, thus very properly deſcribes the *Cupola* and *Corona*, that he ſaw in the *Phaſma* (as he calls it) of *February*. *A little while after new Flames riſing like Spears, the Heaven ſeem'd to be on Fire on the Northern Side quite up to the Zenith. And laſtly, that nothing might ſeem repreſented before which hitherto had happen'd, the Appearance of the Heavens was changed for the Space of an Hour, into the ſtrange Likeneſs of a Box with which they play at Dice, blue and white continually changing, not with leſs Uncertainty and Swiftneſs than the Rays of the Sun, when they are reflected back by an interpoſed Speculum.* Here it is not a little remarkable, that all theſe four already mentioned, fell exactly upon the ſame Age of the Moon, *viz.* [illegible] two Days after the Change.

As to the other of *September* in the ſame Year 1575, theſe are the Words of *Gemma. It was not indeed ſo terrible, yet with greater Vanity that other Phænomenon appear'd, which we ſaw in* October *following, juſt after the Sun was ſet. In this were many ſhining Bows, from which iſſued Spears, Cities with Turrets, and Armies of Soldiers. Hence the Rays proceeded every Way, as alſo the Floating of Clouds and Images of Battles. They fled from and purſued one another, with a wonderful Alternation.* From hence 'tis manifeſt, that this *Phænomenon* appear'd in our Neighbourhood three ſeveral Times, and that with conſiderable Intervals, within the Compaſs of one Year; though our *Engliſh* Hiſtorians have not recorded the two latter; nor did *Gemma* ſee that of *November* 1574, as 'tis moſt likely, by reaſon of Clouds. After this, in the Year 1580, we have the Authority of *Michael** *Maſtlin*; that at *Baknang* in the Country of *Wirtemburg* in *Germany*, theſe *Phaſmata*, as he likewiſe ſtiles them, were ſeen by himſelf no leſs than ſeven Times within the Space of twelve Months. The firſt of theſe, and moſt conſiderable, fell out on the very ſame Day of the Month with ours, *viz.* on *Sunday* the ſixth of *March*, and was attended with much the ſame Circumſtances. And again the ſame Things were ſeen in a very extraordinary Manner on the *9th* of *April* and *10th* of *September*, following: But in a leſs Degree, on the *6th* of *April*, *21ſt* of *September*, *26th* of *December*, and *16th* of *February*, 1581. The laſt of which, and that of the *21ſt* of *September*, muſt needs have been more conſiderable than they then appear'd, becauſe the Moon being near the Full, neceſſarily effaced all the fainter Lights. Of all theſe, however, no one is mentioned in our Annals to have been ſeen in *England*, nor in any other Place that I can find.

(*) *M.* Maſtlin *Lib. de Cometa*, 1580.

The next that we hear of, was that of the Year 1621, on *September 2d, ſt. vet.* ſeen all over *France*, and well deſcrib'd by *Gaſſendus* in his *Phyſicks*, who gives it the Name of *Aurora Borealis*. This, tho' little inferior to what we lately ſaw, and appearing to the Northwards both of *Rouen* and *Paris*, is no where ſaid to have been obſerv'd in *England*, over which the Light ſeem'd to lie.

Another was ſeen all over *Germany*, in the Year 1623, thus deſcrib'd by *Kepler. On the 17 Day of* November, *Anno* 1623, *a fiery Meteor was ſeen, or a burning Ball, flying over all* Germany *from Weſt to Eaſt. In* Auſtria *they ſaid it gave a Sound like a Clap of Thunder, which I cannot think is true; for the Deſcriptions that are extant do not confirm this.*

And ſince then, for above 80 Years, we have no Account of any ſuch Sight, either from home or abroad. The firſt we find on our Books, was one of ſmall Continuance ſeen in *Ireland* by Mr. *Neve*, on the *16th* of *November* 1707. And in the *Miſcellanea Berolinenſia*, publiſhed in 1710, we learn, that in the ſame Year 1707, both on the *24th* of *January*, and *18th* of *February*, *ſt. vet.* ſomething of this

Vid. Supra, p. 134.

kind was ſeen by Mr. *Olaus Romer* at *Copenhagen*, and again on the 23*d* of *February*, the ſame *Aſtronomer* obſerv'd there ſuch another Appearance, but much more conſiderable; of which yet he only ſaw the Beginning, Clouds interpoſing. But the ſame was ſeen that Night by Mr. *Gotfried Kirch*, at *Berlin*, above 200 Miles from *Copenhagen*, and laſted there till paſt ten at Night. To theſe add another ſmall one of ſmall Duration, ſeen near *London*, a little before Midnight between the ninth and tenth of *Auguſt* 1708, by the Lord Biſhop of *Hereford*; ſo that, it ſeems, in little more than eighteen Months, this ſort of Light has been ſeen in the Sky, no leſs than five Times in the Years 1707 and 1708.

Hence we may reaſonably conclude, that the Air, or Earth, or both, are ſometimes, though but ſeldom, and with great Intervals, diſpoſed to produce this *Phænomenon:* For though it be probable that many Times, when it happens, it may not be obſerv'd, as falling out in the Day-time, or in cloudy Weather, or bright Moon-ſhine: Yet, that it ſhould be ſo very often ſeen at ſome Times, and ſo ſeldom at others, is what cannot well be that Way accounted for. Wherefore conſidering what might be moſt probably the *Material Cauſe* of theſe Appearances; what firſt occurr'd was the Vapour of Water rarified exceedingly by ſubterraneous Fire, and tinged with ſulphureous Steams; which Vapour is now generally taken by our Naturaliſts to be the Cauſe of *Earthquakes*. And as Earthquakes happen with great Uncertainty, and have been ſometimes frequent in Places, where, for many Years before and after, they have not been felt; ſo theſe, which we might be allow'd to ſuppoſe produc'd by the Eruption of the pent-up Vapour through the Pores of the Earth, when it is not in ſufficient Quantity, nor ſudden enough to ſhake its Surface, or to open it ſelf a Paſſage by rending it. And as theſe Vapours are ſuddenly produc'd by the Fall of Water upon the Nitro-ſulphureous Fires under Ground, they might well be thought to get from thence a Tincture which might diſpoſe them to ſhine in the Night, and a Tendency contrary to that of Gravity; as we find the Vapours of *Gunpowder*, when heated in *Vacuo*, to ſhine in the Dark, and aſcend to the Top of the Receiver, though exhauſted: The Experiment of which, I ſaw very neatly performed by Mr. *J. Whiteſide*.

Nor ſhould I ſeek for any other Cauſe than this, if in ſome of thoſe Inſtances, particularly this whereof we treat, the Appearance had not been ſeen over a much greater Part of the Earth's Surface than can be thus accounted for. It having in this laſt been viſible from the Weſt Side of *Ireland*, to the Confines of *Ruſſia* and *Poland* on the Eaſt (nor do we yet know its Limits on that Side) extending over at leaſt thirty Degrees of Longitude; and in Latitude, from about fifty Degrees over almoſt all the North of *Europe*; and in all

Places exhibiting at the ſame Time the ſame wondrous Circumſtances as we are informed by the Publick News. Now this is a Space much too wide to be ſhaken at any one Time by the greateſt of Earthquakes, or to be affected by the Perſpiration of that Vapour, which being included, and wanting Vent, might have occaſion'd the Earth to tremble. Nor can we this Way account for that remarkable Particular attending theſe Lights, of being always ſeen on the Northſide of the Horizon, and never to the South.

Wherefore laying aſide the explaining theſe Things by the ordinary Vapours or Exhalations of the Earth or Waters, we are forced to have Recourſe to other ſorts of *Effluvia* of a much more ſubtile Nature, and which perhaps may ſeem more adapted to bring about thoſe wonderful and ſurprizingly quick Motions. Such are the *Magnetical Effluvia*, whoſe Atoms freely permeate the Pores of the moſt ſolid Bodies, meeting with no Obſtacles from the Interpoſition of Glaſs or Marble or even Gold itſelf. Theſe by a perpetual Efflux do, ſome of them, ariſe from the Parts near the Poles of the Magnet, whilſt others of the like Kind of Atoms, but with a contrary Tendency, enter in at the ſame Parts of the Stone, through which they freely paſs; and by a kind of Circulation ſurround it on all Sides, as with an Atmoſphere, to the Diſtance of ſome Diameters of the Body.

That the Fact may be the better comprehended, I ſhall endeavour to exhibit the Manner of the Circulation of the Atoms concern'd therein, as they are expoſed to View, by placing the Poles of a *Terella*, or *Spherical Magnet*, on a Plane, as the Globe on the Horizon of a right Sphere: Then ſtrewing fine Steel Duſt or Filings very thin on the Plane all round it, the Particles of Steel, upon a continued gentle knocking on the underſide of the Plane, will by Degrees conform themſelves to the Figures in which the Circulation is perform'd. Thus, let *A B C D* be a *Terella*, and its Poles *A* the South, and *B* the North; and by doing as preſcrib'd, it will be found that the Filings will lie in a Right Line perpendicular to the Surface of the Ball, when in the Line of the Magnetical Axis continued. But for about forty-five Degrees on either Side, from *B* to *G* or *I*, and from *A* to *H* or *K*, they will form themſelves into Curves, more and more crooked as they are remoter from the Poles; and withal more and more oblique to the Surface of the Stone. Hence it may appear how this exceeding ſubtile Matter revolves; and particularly how it permeates the Magnet with more Force, and in greater Quantity in the circumpolar Parts, entering into it on the one Side, and emerging from it on the other, under the ſame oblique Angles: Whilſt in the middle Zone about *C* and *D*, near the Magnet's Equator (if I may uſe the Word) very few, if any of theſe Particles do impinge, and thoſe very obliquely. *Fig. 24.*

Now by many and very evident Arguments it appears, that our *Globe of Earth* is no other than one great Magnet, or (if I may be allow'd to alledge an Invention of my own) rather two; the one including the other, as the *Shell* includes the *Kernel*; for ſo and not otherwiſe, we may explain the Changes of the Variation of the Magnetical Needle. It ſuffices that we may ſupport the ſame ſort of Circulation of ſuch an exceeding fine Matter to be perpetually performed in the *Earth*, as we obſerve in the *Terella*; which ſubtile Matter freely pervading the Pores of the Earth, and entering into it near its Southern Pole, may paſs out again into the *Æther*, at the ſame Diſtance from the Northern, and with a like Force; its Direction being ſtill more and more oblique, as the Diſtance from the Poles is greater. To this we beg leave to ſuppoſe, that this ſubtile Matter, no otherways diſcovering itſelf, but by its Effects on the Magnetic Needle, wholly imperceptible, and at other Times inviſible, may now and then, by the Concourſe of ſeveral Cauſes very rarely coincident, and to us as yet unknown, be capable of producing a ſmall Degree of Light; perhaps from the greater Denſity of the Matter, or the greater Velocity of its Motion: After the ſame Manner as we ſee the *Effluvia* of *Electric* Bodies by a ſtrong and quick Friction emit Light in the Dark: To which ſort of Light this ſeems to have a great Affinity.

This being allow'd me, I think we may aſſign a Cauſe for many of theſe ſtrange Appearances, and for ſome of the moſt difficult to account for otherwiſe; as why theſe Lights are rarely ſeen any where elſe but in the North, and never, that we hear of, near the Equator: As alſo why they are more frequently ſeen in *Iceland* and *Greenland*, than in *Norway*, though nearer the *Pole* of the *World*. For the Magnetical Poles, in this Age, are to the Weſtward of our Meridian, and more ſo of that of *Norway*, and not far from *Greenland*; as appears by the Variation of the Needle this Year obſerv'd, full twelve Degrees at *London* to the Weſt.

The erect Poſition of the luminous Beams or *Striæ* ſo often repeated that Night, was occaſioned by the riſing of the Vapour or lucid Matter nearly perpendicular to the Earth's Surface. For that any Line erected perpendicularly upon the Surface of the Globe, will appear erect to the Horizon of an Eye placed any where in the ſame ſpherical Superficies; as *Euclid* demonſtrates in a Plane, that any Line erected at right Angles to it, will appear to be perpendicular to that Plane from any Point thereof. That it ſhould be ſo in the Sphere, is a pretty Propoſition, not very obvious, but demonſtrated from *Prop.* 5. *Lib.* 1. *Theodoſii Sphæric.* For by it all Lines erect on the Surface paſs through the Center, where meeting with thoſe from the Eye, they form the Planes of Vertical Circles thereto. And by the Converſe hereof, it is evident, that this luminous

Matter aroſe nearly perpendicular to the Earth's Surface, becauſe it appear'd in this erect Poſition. And whereas in this Appearance, thoſe Beams which aroſe near the Eaſt and Weſt, as *L*, *M*, *N*, were furtheſt from the Perpendicular, on both Sides inclining towards the South, whilſt thoſe in the North were directly upright: The Cauſe thereof may well be explain'd by the Obliquity of the Magnetical Curves, making ſtill obtuſer Angles with the Meridians of the *Terrella*, as they are further from the Poles.

Hence alſo it is manifeſt, how that wonderful *Corona* that was ſeen to the Southwards of the *Vertex*, in the Beginning of the Night, and ſo very remarkable for its tremulous and vibrating Light, was produced; to wit, by the Concourſe of many of thoſe Beams ariſing very high out of the circumjacent Regions, and meeting near the Zenith: The *Effluvia* whereof they conſiſted mixing and interfering one with another, and thereby occaſioning a much ſtronger, but uncertain wavering Light. And ſince it is agreed by all Accounts that this *Corona* was tinged with various Colours, 'tis more than probable, that theſe Vapours were carried up to ſuch a Height, as to emerge out of the Shadow of the Earth, and to be illuſtrated by the direct Beams of the Sun: Whence it might come to paſs that this firſt *Corona* was ſeen colour'd and much brighter than what appear'd afterwards in ſome Places, where the Sight thereof was gone down much lower under the Horizon. Hence too it will be eaſily underſtood that this *Corona* was not one and the ſame in all Places, but was different in every differing Horizon; exactly after the ſame Manner as the Rainbow ſeen in the ſame Cloud is not the ſame Bow, but different to every ſeveral Eye.

Nor is it to be doubted, but the Pyramidical Figure of theſe aſcending Beams is Optical: Since, according to all likelihood, they are parallel-ſided, or rather tapering the other Way. But by the Rules of Perſpective, their Sides ought to converge to a Point, as we ſee in Paintings the Parallel Borders of ſtraight Walks, and all other Lines parallel to the Axis of Viſion, meet as in a Center. Wherefore thoſe Rays which aroſe higheſt above the Earth, and were neareſt the Eye, ſeem'd to terminate in Cuſps ſufficiently acute, and have been for that Reaſon ſuppos'd to repreſent *Spears*. Others ſeen from afar, and perhaps not riſing ſo high as the former, would terminate, as if cut off with Planes parallel to the Horizon, like truncate Cones or Cylinders: Theſe have been taken to look like the Battlements and Towers on the Walls of Cities fortified after the ancient Manner. Whilſt others yet further off, by Reaſon of their great Diſtance, good Part of them being intercepted by the Interpoſition of the Convexity of the Earth, would only ſhew their pointed Tops, and becauſe of their Shortneſs have gotten the Name of *Swords*.

Next the Motion of theſe Beams furniſhes us with a new and moſt evident Argument to prove the diurnal Rotation of the Earth. For thoſe Beams which roſe up to a Point, and did not preſently diſappear, but continued for ſome Time, had moſt of them a ſenſible Motion from Eaſt to Weſt, contrary to that of the Heavens; the biggeſt and talleſt of them, as being neareſt, ſwifteſt; and the more remote and ſhorter, ſlower. By which Means, the one overtaking the other, they would ſometimes ſeem to meet and joſtle; and at other Times to ſeparate, and fly one another. But this Motion was only Optical, and occaſion'd by the Eye of the Spectator being carried away with Earth into the Eaſt; whilſt the exceeding rare Vapour of which thoſe Beams did conſiſt, being raiſed far above the Atmoſphere, was either wholly left behind, or elſe follow'd but with Part of its Velocity, and therefore could not but ſeem to recede and move the contrary Way. And after the ſame Manner as the Stars that go near the Zenith, paſs over thoſe Vertical Circles which border on the Meridian, much ſwifter than thoſe Stars which are more diſtant therefrom; ſo theſe luminous Rays would ſeem to recede faſter from Eaſt to Weſt, as their Baſes were nearer the Eye of the Spectator; and *è contra*, ſlower as they were further off.

Nor are we to think it ſtrange, if after ſo great a Quantity of luminous Vapour had been carried up into the *Æther* out of the Pores of the Earth, the Cauſe of its Efferveſcence at length abating, or perhaps the Matter thereof conſumed; theſe *Effluvia* ſhould at length ſubſide, and form thoſe two bright *Laminæ* which we have deſcrib'd, and whoſe Edges being turn'd to us, were capable to emit ſo much Light. I choſe to call them *Laminæ*, becauſe, without Doubt, tho' they were but thin, they ſpread Horizontally over a large Tract of the Earth's Surface. And whilſt this luminous Matter dropp'd down from the upper Plate to the under, the many little white Columns were formed between them by its Deſcent, only viſible for the Moment of their Fall. Theſe by the Swiftneſs with which they vaniſh'd, and their great Number, ſhewing themſelves, and diſappearing without any Order, exhibited a very odd Appearance; thoſe on the Right ſeeming ſometimes to drive and puſh thoſe on the left, and *vice verſa*.

I have omitted ſeveral Particulars of leſs Moment: But theſe are the principal *Phænomena*; of whoſe Cauſes I ſhould have with more Certainty given my Thoughts, if I had ſeen the whole from Beginning to End; and could have added my own Remarks to the Relations of others; and eſpecially, if we could by any Means have come at the Diſtances thereof. If it ſhall by any be thought a hard Suppoſition that I aſſume the *Effluvia* of the Magnetical Matter for this Purpoſe, which in certain Caſes may themſelves become luminous, or rather may ſometimes carry with them out of the Bowels of the Earth, a ſort of Atoms proper to produce Light in the *Æther*. I anſwer, that we are not as yet acquainted with any other Kinds of *Effluvia* of terreſtrial Matter, which may ſerve for our Purpoſe, than thoſe we have here conſider'd, *viz.* the magnetical Atoms, and thoſe of Water highly rarified into Vapour. Nor do we find any Thing like it in what we ſee of the celeſtial Bodies, unleſs it be the *Effluvia* projected out of the Bodies of Comets to a vaſt Height, and which ſeem by a *Vis centrifuga* to fly with an incredible Swiftneſs the Centers both of the Sun and Comet, and to go off into Tails of a ſcarce conceivable Length. What may be the Conſtitution of theſe Cometical Vapours, we Inhabitants of the *Earth* can know but little, and only that they are evidently excited by the Heat of the Sun; whereas this Meteor ſeldom is ſeen but in the Polar Regions of the World, and that moſt commonly in the Winter Months.

I beg Leave on this Occaſion, to mention what, near 25 Years ſince, I publiſh'd in N° 195 † of theſe *Tranſactions*, *viz.* That ſuppoſing the *Earth* to be concave, with a leſſer Globe included, in order to make that inner Globe capable of being inhabited, there might not improbably be contain'd ſome luminous *Medium* between the Balls, ſo as to make a perpetual Day below. That very great Tracts of the Ætherial Space are occupied by ſuch a ſhining *Medium*, is evident from former Inſtances *. And if ſuch a *Medium* ſhould be thus incloſed within us, what ſhould hinder but that we may ſuppoſe that ſome Parts of this lucid Subſtance may, on very rare and extraordinary Occaſions, tranſude through and penetrate the *Cortex* of our *Earth*, and being got looſe, may afford the Matter whereof this our *Meteor* conſiſts. This ſeems favour'd by one conſiderable Circumſtance, *viz.* that the *Earth*, becauſe of its diurnal Rotation, being neceſſarily of the Figure of a flat *Spheroid*, the Thickneſs of the *Cortex*, in the *Polar* Parts of the Globe, is conſiderably leſs than towards the *Equator*; and therefore more likely to give Paſſage to theſe Vapours: Whence a Reaſon may be given why theſe Lights are always ſeen in the North.

† *Vid.* Supra, V. II. C. IV. p. 615.

* *Vid. Supra* C. III. S. V.

A Deſcription of the ſame Phænomenon *ſeen on the* Ocean. n. 348. p. 430.

2.] At *Paris*, the Light was ſo inconſiderable, that it was not regarded: But a Letter to Mr. *Alexander Geekie*, Surgeon, dated on Board a Ship in *Nevis* Road in *America*, *April* 19, 1716, informs us, "That on the ſixth of *March*, at Nine a Clock in the Evening, we being then in the Latitude of 45° 36' (off of the N. W. Coaſt of *Spain*); A clear Cloud appear'd Eaſt to us, not far diſtant from our Zenith, which afterwards darted itſelf forth into a Number of Rays of Light, every way like the Tail of a Comet, of ſuch a great Length, that it reach'd within a ſhort

" Way of the Horizon. There likewiſe appear'd a Body of Light,
" N. N. E. of us, and continued as light almoſt as Day, till after
" 12 a Clock. It appear'd at a good Diſtance from us, and darken'd
" on a ſudden.

Hence it ſhould ſeem, that the Vapour which cauſed this Appearance, aroſe indifferently out of the deep Ocean Sea, as well as from the Land; by which we may conclude the great Subtilty of the Matter thereof, ſince it could permeate ſo great a Quantity of Water, and yet retain its Velocity.

A return of the ſame, *ibid.*

3.] Since this, moſt of the ſame *Phænomena* have been repeated three ſeveral Nights ſucceſſively, *viz.* on the laſt of *March*, and firſt and ſecond of *April*. The beſt and fulleſt Deſcription of the two firſt, is, from a Letter of Dr. *B. Taylor*, dated *April* 2, from *Cott rſtock*, near *Oundle* in *Northamptonſhire*, who thus deſcribes them. " On *Saturday* " Night laſt, and laſt Night, I ſaw Appearances of the ſame Kind, " with thoſe of *March* 6, but not to compare for Extent and Strength. " They both began ſoon after Sun-ſet, and continu'd till after 12, but " how much longer, I cannot tell. They were both about 10 or 15 " Degrees to the Weſtward of the North, and took up about 80 De-" grees of the Horizon; and the *Aurora* roſe about 30 gr. high, with " a dark Bottom, like what was ſeen in the firſt; and from whence " there ſprung out ſeveral Bodies of Light, which immediately ran in-" to Streams, aſcending about 30, or at moſt 40 gr. high. There " was no flaſhing nor waving Light, but, in all other Reſpects, theſe " Lights were of the ſame Kind with what we ſaw at *London*. Indeed " in that laſt Night, there was one *Phænomenon* like the flaſhing Light; " for a Body of Light about 15 or 20 Degrees long, parallel to the " Horizon, roſe till it came about 6 Degrees above the black " Baſis, and then ſent up two ſtrong Streams of Light about " 40 gr. high, which at Top daſh'd againſt one another, and diſap-" pear'd.

At *London*, the firſt Night, *March* 31. It did not begin to radiate, till towards Midnight, and was ſeen but by few, the Beams not riſing very high, and ſcarce appearing over the Houſes; but by the Relation of thoſe that ſaw it, it was much more conſiderable than the next Night following *Eaſter-day*; for it then ſent out but few, and very ſhort Beams, moſtly terminating in a ſharp Point, and preſently diſappearing: Only it beginning to ſtream as ſoon as it became duſky, it was very obſervable, that thoſe Rays which aroſe out of the Weſt-end of the luminous Arch, next the Sun, were enlighten'd by its Beams, and ſhew'd themſelves much brighter than thoſe which aroſe under the Pole, or to the Eaſtward thereof. And after nine, till Midnight, no more Beams aroſe; and the luminous Arch with its black Baſis, ſettled down very low in the Northern Horizon.

The ſame two Nights, by the Obſervation of Mr. *William Lingen*, the like Appearance was ſeen at *Dublin*, about the Hours of nine or ten; at which Time, in the former Night, it was near as light as in a Moonlight Night. And from *France*, we have an Account, that both thoſe Nights, the ſame was ſeen at *Paris*, with much the ſame Circumſtances as at *Dublin*. So that, it ſeems, this Meteor, though no Ways comparable to that of the 6th of *March*, was ſeen not leſs than 150 Leagues, and probably much farther.

On *April* 2. when it began to be dark, a luminous Arch appear'd in the North, with a very narrow black Bottom under it, very low, and depreſs'd to the Horizon; nor was it ſeen at, or about *London*, to project any pointed Rays as the former.

But what was moſt remarkable that Evening, was, what was ſeen at *London*, by *Martin Folkes*, Eſq; about nine that Night. He being then in the open Air, ſaw in an Inſtant, a bright Ray of very white Light, appear in the Eaſt, out of the pure Sky, then very ſerene and ſtill; it very much reſembled the Tail of a Comet, and was about 20 gr. inclin'd from the Perpendicular to the Right, beginning about γ of *Bayer* in the *Corona Borea*, and terminating about the *Informis*, by ſome call'd *Cor Caroli*. This having appear'd but a very little Time, diſappear'd at once, as in a Moment: When, on a ſudden, ſuch another Beam was inſtantly produced, not exactly in the ſame Place, but in the ſame Situation. Its lower being about 20 gr. high, was terminated exactly between κ and γ, in the Right Hand and Arm of *Hercules*, and the Middle of it paſs'd over σ and ϱ in the Girdle of *Bootes*, and thence proceeded Weſtwards, leaving *Cor Caroli* four or five Degrees to the Northwards. After it had continu'd in this Poſition near ten Minutes immoveable among the Stars, it began to move ſlowly towards the North: And the lower End paſſing over the Northern Edge of the *Crown*, and the Ray itſelf over *Cor Caroli*, it grew fainter, and vaniſh'd, having continued in all about 20 Minutes. This latter, with ſome Interruptions, was extended between *Caſtor* and *Pollux*, very far into the Weſt: And about that Time, the ſame, or ſuch another Beam, was ſeen at St. *Aſaph*, by Dr. *Stanley*.

XXVII. 1.] On *February* 5, 1716-17, at eight at Night, at *Sutton at Hone* in *Kent*, an *Aurora Borealis* appear'd. It occupied at leaſt $\frac{1}{3}$ or near $\frac{1}{6}$ of the Horizon; it was low, and ſhot out bright Rays, and, I believe, would have appear'd very light, had it not been that the Moon ſhone at the ſame Time, being about five Days old, and that the *Aurora* diſappear'd before the Moon ſet.

Two Northern Auroras *ſeen in* Kent, *by the Reverend Mr.* E. Barrel. n. 351. p. 584.

Again, on the 30th of *March* following, there was another *Aurora Borealis*. I ſaw it not till paſt nine: 'Twas dim then, and its higheſt Part cover'd the loweſt Star in *Caſſiopea's Chair*. It did not ſeem due

North, but one Point to the Weſt. About ten it ſhot out very bright Rays, high, and tending ſomewhat towards one another. Near eleven a Clock, there was (beſides the Northern Brightneſs) a long Streak, not very broad, extended Eaſt and Weſt; which beginning in the *Serpent's Head*, near *Hercules's Club*, and covering *Arcturus*, proceeded near *Berenice's Hair*, and ſo went over *Cor Leonis*, and thence to the *Canicula*, and ended a little beyond that Star. It ſhone very bright at firſt, but faded away in about eight or nine Minutes. If it had Motion (which I am not ſure of) it was ſouthward. I waited for the next Fit of Brightneſs of the *Aurora*; and in about ſeven Minutes, the eaſtern Part of the Streak, *viz.* from the *Serpent's Head* to near *Berenice's Hair*, became viſible again, though dim, and was quite effaced in four or five Minutes more: And I did not yet perceive any Change of its Place.

—one *of them ſeen at* London, *by* M. Folkes, *Eſq;* n. 352. p. 586.

2.] Being in the Street, between eight and nine a Clock, on *March* 8, 1717, I perceiv'd a Light over the Houſes to the Northwards, little inferior to that the Full Moon gives when ſhe firſt riſes. Upon this, I made all the Haſte I could into the Fields, where I was for ſome Time entertain'd with the Sight of an *Aurora Borealis*, attended with moſt of the *Phænomena* of that very remarkable one of the 6th of *March* 1715-16.

The whole Northern Part of the Horizon was in the ſame Manner cover'd with ſomewhat reſembling a very black Cloud, from behind which, there iſſued a conſiderable Light, whoſe lower Part was pretty well defin'd by the common Edge of the Cloud, but the upper died away more gradually. This upper Limb of the Light reſembling the Arch of a Circle, whoſe higheſt Point between nine and ten of the Clock (when the Meteor was moſt conſiderable) was elevated about 12 Degrees, and bore, as I imagin'd, about 20 Degrees weſtward of the due North. It touch'd the Horizon in the Weſt, at the Diſtance of about 65 or 70 Degrees from the North, whence the whole intercepted Arch of the Horizon would have been of near 100 Degrees, had not ſome few Degrees in the Eaſt been hid by Clouds, which lay between us and the Meteor.

The ſeeming black Cloud, when I firſt ſaw it, ran nearly parallel to the Horizon, and at the Diſtance of 6 or 7 Degrees, but in about Half an Hour, it changed its Figure very much, ſinking down in the North to about half its Height, and riſing in the Weſt near as much. What I principally took Notice of this for, was, that the Light iſſuing from behind it, did not change with it, but remain'd of the ſame Figure, however the Cloud approached, or receded from differing Parts of its Limb.

There aroſe at firſt, ſome Streams in the N. N. W. but of no conſiderable Length, few of them paſſing 5 Degrees above the Arch; but beginning from behind the ſeeming Cloud, ſo as to be about 12 Degrees high in all. They were pointed at the Ends, and nearly Vertical to the Horizon. Between Times there was nothing but the Arch to be ſeen, and that only reſembling a common *Aurora*; and again in an Inſtant, by a ſort of a tremulous Motion, ſeveral Parts of it would appear converted into a vaſt Number of parallel Streams, for the moſt Part very little higher than the Arch itſelf. About 20 Minutes before Ten, a ſmall Part of the Arch, almoſt due North, grew remarkably lighter than the reſt, and continued to increaſe for about half a Minute; when there ſuddenly broke out ſome very tall Streams of at leaſt 60 Degrees high, as I found by one in particular, which aroſe full North, and paſſing over the Pole Star itſelf, reach'd ſome Degrees beyond it. This was the moſt remarkable Time of the Appearance; ſome ſuch Lances, though not ſo high, immediately ſhooting out of the Place that firſt of all radiated, as did ſome more a good way to the Eaſt. They were all nearly perpendicular to the Horizon, and moſt of them did ariſe quite from the black Subſtance at Bottom, tho' I ſaw ſome few that did not reach ſo low, appearing as if their lower Parts had been broken off. Some of them were full as bright as any I ſaw the laſt Year, the Axes (if I may ſo call them) of ſome of the talleſt Streams coming up very near to the Colour of that pale Fire we ſee in ſome Sorts of Lightning.

About this Time the Ground Weſtward was all cover'd with an odd ſort of Miſt, the ſame from which I remember laſt Year, a great many People ſaid there came an ill Smell, which I did not at all perceive.

About 10 the *Phænomenon* very much decreas'd, and ſo continu'd till after 11, only ſending up now and then two or three Streams; at half an Hour after 11 it was again pretty much increas'd, and I ſaw it again ſend out ſome Streams almoſt as conſiderable as I had before ſeen this Evening; the Arch yet continu'd, but not ſo entire; and from what I could judge, its middle was ſome Degrees nearer the North, than when I firſt took Notice of it. Till a Quarter of an Hour before 12 the Light continually abated, and then I left it; but I was inform'd that it continu'd till towards Day-break, but never ſtream'd remarkably after I went away.

Though I could not this Time ſee any Stars through the black Matter at Bottom, I am ſenſible it was not a Cloud, though it bore the Reſemblance of one: For when a real Cloud (as ſeveral ſmall ones did) came over any Part of it, their Difference was very conſpicuous.

I have ſince receiv'd two Letters, one from *Wiſbich* in the Iſle of *Ely*, the other from within 14 Miles of the *Bath*, both which take Notice of it, though with no further Particulars, than that they had ſeen the ſame Light, tho' not conſiderable, as in the Beginning of *March* the laſt Year.

An Account of an extraordinary Meteor, *&c. by Dr.* E. Halley. n. 360. p. 978.

XXVIII. On the 19*th* of *March* 1718-19, a wonderful Luminous Meteor was ſeen in the Heavens all over *England*. Some of its *Phænomena* are very hard to account for, according to the Notions hitherto receiv'd by our Naturaliſts; ſuch is the very great Height thereof above the Earth; the vaſt Quantity of the Matter; the extravagant Velocity wherewith it mov'd; and the prodigious Exploſions heard at ſo great a Diſtance, whoſe Sound, attended with a very ſenſible Tremor of the ſubject Air, was certainly propagated through a *Medium* incredibly rare, and next to a *Vacuum*.

† *Vid.* Supra. p. 135.

I have formerly † collected what I could find of ſuch Meteors, but none ſeem to come up in any Circumſtance to this late Appearance; of which I ſhall give an Account from the many Relations thereof communicated to the *Royal Society*; tho' it was not my good Fortune to ſee it myſelf.

Sir *Hans Sloan* being Abroad at that Time, happen'd to have his Eyes turn'd towards it, in its very firſt Eruption; and gave me an Account of it in the following Terms: " That paſſing along Eaſtward by the N. E. Corner of *Southampton-ſtreet* in *Bloomſbury-Square*, " *London*, at about a quarter after Eight at Night, I was ſurpriz'd to " ſee a ſudden great Light, much beyond that of the Moon, which " ſhone then very bright. I turn'd to the Weſtward where the " Light was; which I apprehended at firſt to be artificial Fireworks or Rockets. The firſt Place I obſerv'd it in, was about " the *Pleiades* Northerly, whence it mov'd after the Manner of, but " more ſlowly than a falling Star, in a ſeeming direct Line, deſcending a little beyond, and withal below, the Stars in *Orion's* " *Belt*, then in the S. W. The long Stream appear'd to me to be " branch'd about the Middle, and the *Meteor* in its Way turn'd " Pear-faſhion'd, or tapering upwards. At the lower End it came " at laſt to be bigger and ſpherical, tho' it was not ſo big as the " Full Moon. The Colour of it was whitiſh, with an Eye of " Blue, of a moſt vivid dazling Luſtre, which ſeem'd in Brightneſs very nearly to reſemble, if not ſurpaſs that of the Body of " the Sun in a clear Day, beheld by the naked Eye. This Brightneſs oblig'd me to turn my Eyes (which had their Pupils adapted " to the Light of the Moon) from it ſeveral Times, as well " when it was a Stream, as when it was Pear-faſhion'd and a " Globe; tho' I had a great Curioſity to obſerve it with Attention. " It ſeem'd to move in about half a Minute or leſs, about the " Length of 20°, and to go out, as I gueſs'd, about as much above the Horizon. There was left behind it, where it had

“ paſs'd, a Track of a cloudy or faint reddiſh yellow Colour, ſuch as red-hot Iron or glowing Coals have, which remain'd more than a Minute, ſeem'd to ſparkle, and kept its Place without falling. This Track was interrupted, or had a Chaſm towards its upper End, and about two Thirds of its Length. I did not hear any Noiſe it made, but the Place where the Globe of Light had been, remain'd after it was extinct, of the ſame reddiſh yellow Colour with the Stream for ſome Time, and at firſt ſome Sparks ſeem'd to iſſue from it, ſuch as come from red-hot Iron beaten on an Anvil.

All the Relations agree in this, that the Splendor was little inferior to that of the Sun; that within Doors the *Candles* gave no Manner of Light; and in the Streets, not only all the *Stars* diſappear'd, but the *Moon* then nine Days old, and high towards the Meridian, the Sky being very clear, was ſo far effaced as to be ſcarce ſeen, at leaſt not to caſt a Shade, even where the Beams of the Meteor were intercepted by the Houſes: So that for ſome few Seconds of Time, in all reſpects it reſembled perfect Day.

The Time when this happened was generally reckon'd at a Quarter paſt Eight; but by the accurate Account of the Reverend Mr. *Pound* (who only ſaw the Light) agreeing with what has been ſent us from the *Pariſian* Obſervatory, it appears to have been at $8^h\ 8'$ apparent Time at *London*. And the Sun being then in 9½ *gr.* of *Aries*, the right Aſcenſion of the Mid-Heaven was 130 *gr.* 45', whereby the Poſition of the Sphere of fix'd Stars is given. Hence the *Lucida Pleiadum* will be found at that Time to have been 25½ *gr.* high, in an *Azimuth* 6 *gr.* to the Northward of the Weſt, and conſequently the Arch the Meteor mov'd in, was inclin'd to the Horizon with an Angle of about 27 *gr.* having its Node or Interſection therewith, nearly *South South Weſt*; as will more plainly appear from what follows:

At *Oxford*, five Minutes earlier, Mr. *John Whiteſide*, Keeper of the *Aſhmole Muſæum*, immediately after the Extinction of the Meteor, made Haſte out to ſee what it might be, and well conſider'd the Situation of the Track it had left in the Sky: He found it to have paſs'd about 1½ Degree above the preceding Shoulder of *Orion*, and about 3½ *gr.* above the middle of his *Belt*, where there appear'd a luminous *Nubecula* of a reddiſh Light, being a Dilatation of the Track, ſeeming to have been occaſion'd by ſome Exploſion there; and by what he could learn from thoſe that ſaw it, it was thereabout that it broke out, and firſt began to efface the Stars. Hence it proceeded as to Senſe in an Arch of a great Circle, and paſſing in the middle between the Tail of *Lepus* (θ *Bayero*) and β in the Fore-foot of *Canis major*, it terminated about ξ in the Breaſt of the ſame, nearly in 95 *gr.* of Right-Aſcenſion, with 23 *gr.* South Declination:

clination: and at the Place of its Extinction there remain'd a large whitiſh *Nebula*, much broader and of a ſtronger Light than the reſt of the Track, which he took for a certain Sign of a very great Exploſion made there. By Computation it will be found that the Angle this Track made with the Horizon of *Oxford* was neareſt 40 *gr.* and its Interſection due S. S. W; and that the Place of its Extinction was about 9 *gr.* above the Horizon, in the Azimuth of 32 *gr.* to the Weſt.

At *Worceſter*, Mr. *Nicholas Fatio* ſaw this Meteor deſcend obliquely towards the South, making an Angle with the Horizon of about 65°, and interſecting it about S. S. W. ½ *S.* as may be collected from a Scheme thereof ſent up by him to the *Royal Society*. By this the Track left all *Orion* and *Canis major* to the Weſtward, and divided the Diſtance between *Sirius* and *Procyon*, ſo as to be almoſt twice as far from *Procyon* as *Syrius*. The Time here was one Minute before Eight, this City being about 9′ of Time to the Weſt of *London*, and conſequently the Right-Aſcenſion of the Mid-Heaven 128 ½ *gr.*

Now the Situation of the three Cities, *London*, *Oxford*, and *Worceſter* being nearly on the ſame W. N. W. Point, whereon the Track of the Meteor had its greateſt Altitude above the Horizon, equal to the Angle of its viſible Way; if we ſuppoſe it at *London* to have been 27 *gr.* high, and at the ſame Time at *Worceſter* to be 65 *gr.* high, in the Plane of the Vertical Circle paſſing through *London* and *Worceſter*; ſuppoſing likewiſe the Diſtance between them, to be 90 Geographical Miles, or one Degree and half of an Arch of a great Circle of the Earth, we may by a Trigonometrical *Calculus* find the perpendicular Height to have been 64 ſuch Miles; and the Point over which it was then perpendicular to have been 30 ſuch Miles W. N. W. from *Worceſter*. And the Geographical Mile to the *Engliſh* Statute Mile being as 23 to 20, this Height will be no leſs than 73 ½ *Engliſh* Miles. The Place alſo directly under it, will be found to be about *Preſtain* on the Confines of *Hereford* and *Radnor*-Shires. The *Oxford* Obſervation too concurs nearly in the ſame Concluſion.

This Altitude being added to the Semidiameter of the Earth as *Radius*, becomes the *Secant* of eleven Degrees, ſo that the Meteor might be ſeen above the Horizon in all Places not more than 220 Leagues diſtant from it. Whence it will not be ſtrange that it ſhould be ſeen over all Parts of the Iſlands of *Great Britain* and *Ireland*, over all *Holland*, and the hither Parts of *Germany*, *France* and *Spain*, at one and the ſame Inſtant of Time.

Having thus fix'd one Point in the Line of its Motion, let us ſee what Courſe the Meteor took from thence; and firſt at the Town of *Kirkby-Stephens*, on the Borders of *Yorkſhire* and *Weſtmorland*, in a Meridian very little to the Weſtward of *Worceſter*, but about 2½ *gr.* more to the North, it was obſerv'd to break out as from a duſky Cloud, directly under the Moon, and from thence to deſcend, nearly in a Perpendicular, almoſt to the Horizon. Now the Moon being at that Time in the third Degree of *Leo*, was about half an Hour paſt the Meridian, and conſequently much about a Point to the Weſt, or S. *by* W. and the Situation of *Preſtain* from *Kirkby-Stephens*, being ſufficiently near upon the ſame Point, it follows, that the Direction of the Track of the Meteor was according to the great Circle paſſing over thoſe two Places.

And this is further confirm'd by the Obſervation of *Sam. Cruwys*, Eſq; who at *Tiverton*, about twelve Geographical Miles, nearly due North from *Exeter*, obſerv'd the firſt Exploſion of this Meteor exactly in his Zenith, as he was aſſur'd by applying his Eye to the Side of his Door, which he took to be perpendicular, and looking upwards: And from thence he ſaw it deſcend to the Southward directly in the ſame Azimuth, without declining either to the Right or Left: Hence it it plain, that the Track likewiſe paſs'd over this Place, which by our Maps is found to lie in a Line with *Preſtain* and *Kirkby-Stephens*.

On this Suppoſition, that the firſt Exploſion, attended with the reddiſh *Nubecula*, was directly over *Tiverton*, let us compare the *Oxford* Obſervation with it, in order to determine more nicely the perpendicular Altitude there. At *Oxford* this *Nubecula* was found to be 3½ *gr.* above the middle Star of *Orion's Girdle*, at $8^h\ 3'$, and was therefore 26½ *gr.* above the Horizon; and the Diſtance between *Oxford* and *Tiverton*, being 1° 55′, or 115 Geographical Miles, it will be as the Sine of 61° 35′, to the Sine of 63° 30′. So the Semidiameter of the Earth being 3437¼ ſuch Miles, to 3498 Miles, the Diſtance of the Meteor from the Center of the Earth; from which deducting the Semidiameter, there remain 60¼ Geographical Miles for the Height of the Meteor above *Tiverton*: This is confirmed by the Obſervation of the Reverend Mr. *Derham*, who at *Windſor* ſaw the aforeſaid *Nubecula* about two Degrees above the moſt Southerly of the Seven Stars in the Shield of *Orion*; that is (the Time being $8^h\ 6'$) in the Altitude of 23½ *gr.* Whence the Diſtance between *Tiverton* and *Windſor*, being 150 meaſur'd Miles, or 130 Geographical, by a like Proportion, we ſhall find the ſame Height of the Meteor 60 ſuch Miles, wanting only one Quarter. So that in a Round Number we may conclude it to have been juſt 60 Geographical, or 69 Statute Miles, above the Earth's Surface. Nor is it poſſible to come at a preciſe Determination of this Matter, by reaſon of the Inaccuracy of our *Data*, which were only the Notes of Perſons under the Surprize of the Suddenneſs of the Light, and no ways pretending to Exactneſs: However, ſuch as they are, they abundantly evince the Height thereof to have exceeded 60 *Engliſh* Miles, not to ſay 38 or 40, as ſome would have it.

I was unwilling to leave off, till I had pitch'd upon ſome Hypotheſis that might ſubject the Motion of this Meteor to a *Calculus*, that the Curious might be able to compute the viſible Way thereof, either in reſpect of the Horizon, or among the Fix'd Stars. This I found might be perform'd with tolerable Exactneſs, ſuppoſing that it mov'd in the Arch of a Circle concentric with the Earth, but 60 Geographical Miles without it; and that the Point of the firſt Exploſion was over the Latitude of 50° 40′, and 3° 40′ to the Weſt of *London*; and that of the laſt Extinction over Lat. 47° 40′, with 4° 50′ Weſt Longitude: The Time being fix'd to 8 Minutes paſt Eight at *London*. Hence it is eaſy, by a Trigonometrical Proceſs, to obtain the viſible Altitude and Azimuth of the Meteor at either of its Exploſions, as ſeen from any Place whoſe Longitude and Latitude is known; and from the Time given, the Points in the Sphere of Stars anſwering to thoſe Azimuths and Altitudes are readily deduced. Let thoſe that contend for a much leſs Height of this Meteor, try if they can, on ſuch their Suppoſition, reconcile the ſeveral *Phænomena* before recited with one another, and with the Obſervation of the Reverend Mr. *William Ella*, between *Gainſborough* and *Redford*. Here at 8^{h} 5′, the Meteor was ſeen to paſs preciſely in the Middle between *Sirius* and the Fore-foot of *Canis major*, moving obliquely to the Southward, in a Line whoſe Direction ſeem'd to be from the Middle between the two Shoulders of *Orion*. The Latitude of the Place being nearly 53° 20′, and Longitude Weſt from *London* 0° 45′. Let them try how they can account for its being ſeen five Degrees high at *Aberdeen* in *Scotland*, and near as much at *Peterhead*, half a Degree more northerly: And then let them judge whether it did not exceed the reputed Limits of our Atmoſphere. Laſtly, if the apparent Altitude of the Meteor at *Paris* was not 5½, but 11 *gr.* on the W. *by* N. Point, when it muſt have been in its greateſt Luſtre, there will be no Pretence to bring it lower than I have made it, eſpecially if it be allow'd to have follow'd the Track I have aſſign'd it, over *Preſtain*, *Cardiff*, *Minehead*, *Tiverton*, and *Breſt* in *Britany*.

Allowing this to have been the Path it mov'd in, the real Magnitude and Velocity of this Meteor might be aſſign'd, if the ſeveral Accounts of its apparent Diameter, and of the Time of its Paſſage from one of its Exploſions to the other, were conſiſtent. But ſome of them making its viſible Appearance nearly equal to the Sun's, which, in the Opinion of many, it far exceeded, we may ſuppoſe with the leaſt, that, at the Time when it firſt broke out over *Tiverton*, its Diameter was half a Degree. And its horizontal Diſtance being 150 Geographical Miles from *London*, and its Altitude 60, the Hypothenuſal or real Diſtance from the Eye, will be more than 160 ſuch Miles; to which Radius the Subtenſe of half a Degree will be above an *Engliſh* Mile and half, being about 2800 Yards *quamproxime*. After the ſame Manner it is difficult to aſſign its Velocity, whilſt ſome make it half, others leſs than a Quarter, of a Minute, in paſſing from its firſt Exploſion to its laſt Extinction; But the Diſtance it mov'd in that Time being about 3 *gr.* or 180 Geographical Miles, we may modeſtly compute it to have run above 300 ſuch Miles in a Minute; which is a Swiftneſs wholly incredible, and ſuch, that if a heavy Body were projected horizontally with the ſame, it would not deſcend by its Gravity to the Earth, but would rather fly off, and move round its Center in a perpetual Orb, reſembling that of the *Moon*.

Of ſeveral Accidents that were reported to have attended its Paſſage, many were the Effect of Fancy; ſuch as the hearing it hiſs as it went along, as if it had been very near at Hand: Others imagin'd they felt the Warmth of its Beams; and ſome there were that thought, at leaſt wrote, that they were ſcalded by it. But what is certain, is, the wonderful Noiſe that follow'd its Exploſion. All Accounts from *Devon* and *Cornwal*, and the neighbouring Counties, are unanimous, that there was heard there, as it were, the Report of a very great Cannon, or rather of a Broadſide, at ſome Diſtance, which was ſoon follow'd by a rattling Noiſe, as if many ſmall Arms had been promiſcuouſly diſcharg'd. What was peculiar to this Sound, was, that it was attended with an uncommon Tremor of the Air, and every where in thoſe Counties, very ſenſibly ſhook the Glaſs-windows and Doors in the Houſes, and according to ſome, even the Houſes themſelves, beyond the uſual Effect of Cannon, though near; and Mr. *Cruwys* at *Tiverton*, loſt a Looking-Glaſs, that being looſe in its Frame, fell out on the Shock, and was broken. Nor do we yet known the Extent of this prodigious Sound, which was heard, againſt the then Eaſterly Wind, in the Neighbourhood of *London*, as I am inform'd; and by the learned Dr. *Tabor*, who diſtinctly heard it beyond *Lewes* in *Suſſex*; but whether the Report heard near *Lewes* were of that Exploſion right over *Devonſhire*, or rather of that latter, and much greater at the Extinction over *Britany*, I ſhall not undertake to determine, till we have ſome further Accounts from *France*, whence, hitherto, we have only had, that at *Paris*, the Time of the Appearance was at 17 Minutes paſt Eight.

It remains to attempt ſomething towards a Solution of the uncommon *Phænomena* of this Meteor; and by comparing them with Things more familiar to us, to ſhew at leaſt how they might poſſibly be effected. And firſt, the unuſual and continued Heats of the laſt Summer in theſe Parts of the World, may be ſuppos'd to have excited an extraordinary Quantity of Vapour of all Sorts; of which the aqueous, and moſt others, ſoon condens'd by Cold, and wanting a certain Degree of ſpecific Gravity in the Air to buoy them up, aſcend but to a ſmall Height, and are quickly return'd in Rain, Dews, *&c.* whereas the inflammable ſulphureous Vapours, by an innate Levity, have a ſort of *Vis centrifuga*, and not only have no need of the Air to ſupport them, but being agitated by Heat, will aſcend in *Vacuo Boileano*, and ſublime to the Top of the Receiver, when moſt other Fumes fall inſtantly down, and lie like Water at the Bottom; the Experiment whereof was firſt ſhewn me by the Reverend Mr. *Whiteſide.* By this we may comprehend how the Matter of the Meteor might have been raiſed from a large Tract of the Earth's Surface, and aſcend far above the reputed Limits of the Atmoſphere; where, being diſingag'd from all other Particles, by that Principle of Nature that congregates *Homogenea* viſible in ſo many Inſtances, its Atoms might in Length of Time coaleſce and run together, as we ſee Salts ſhoot in Water; and gradually contracting themſelves into a narrower Compaſs, might lie like a Train of *Gunpowder* in the *Æther*, till catching Fire by ſome internal Ferment, as we find the Damps in Mines frequently do, the Flame would be communicated to its continued Parts, and ſo run on like a Train fir'd.

This may explain how it came to move with ſo unconceivable a Velocity; for if a continued Train of Powder were no bigger than a Barrel, it is not eaſy to ſay how very faſt the Fire would fly along it; much leſs can we imagine the Rapidity of the Accenſion of theſe more inflammable Vapours, lying in a Train of ſo vaſt a Thickneſs. If this were the Caſe, it was not a Globe of Fire that ran along, but a ſucceſſive kindling of new Matter: And as ſome Parts of the Earth might emit theſe Vapours in greater Plenty than others, this Train might in ſome Parts thereof be much denſer and bigger than in others, which might occaſion ſeveral ſmaller Exploſions, as the Fire ran along it, beſides the great ones, which were like the blowing up of Magazines. Thus we may account for the rattling Noiſe like ſmall Arms, heard after the great Bounce on the Exploſion over *Tiverton:* The Continuance of which for ſome Time, argues, that the Sound thereof came from Diſtances that increaſed.

What may be ſaid to the Propagation of the Sound through a *Medium*, according to the receiv'd Theory of the Air above 300000 Times rarer than what we breathe, and next to a *Vacuum*, I confeſs I know not. Hitherto we have concluded the Air to be the Vehicle of Sound: And in our artificial *Vacuum*, we find it greatly diminiſh'd: But we have this only Inſtance of the Effect of an Exploſion of a Mile or two Diameter, the Immenſity of which may perhaps compenſate the extreme Fineneſs of the *Medium*.

An Account of an Extraordinary Aurora Borealis *at* London, *Nov.* 10. 1719. *by Dr.* E. Halley. n. 363. p. 1099.

XXIX. 1.] On *November* 10, 1719, in the Morning, about five of the Clock (as I was obſerving *Jupiter*) I found certain white Streaks in the Sky, ſeeming nearly perpendicular; which, whilſt I conſider'd them, ſeem'd inſtantly to vaniſh, and ſoon after others came as inſtantaneouſly in their Room: Looking up towards the *Zenith*, I perceiv'd an entire *Canopy* of ſuch kind of white *Striæ*, ſeeming to deſcend from a white Circle of faint Clouds, about 7 or 8 Degrees in Diameter, which Circle ſometimes would vaniſh on a ſudden, and as ſuddenly be renew'd. I obſerv'd that the Center of this Place of Concourſe was not exactly in the *Zenith*, but rather 14 Degrees to the Southwards thereof; which I eſtimated by a Star, which on each Return thereof ſhew'd its ſelf about the Center of the Circle. This Star is the 33*d* Star of the *Great Bear* in *Tycho*'s Catalogue, whoſe Diſtance from the Pole at this Time is 52½ Degr. and which about half an Hour paſt Five that Morning paſs'd the Meridian; ſo that thoſe Rays center'd very nearly on the Meridian itſelf. It was a very entertaining Sight, till the Day-break began to obſcure theſe Lights, which were but faint, though ſufficiently diſtinguiſhable. They came none of them lower than to about 30 or 40 Degr. of Altitude, and ſeem'd not to have aſcended from the Horizon. The Sky was perfectly ſerene and calm, which ſeems to be one of the concomitant Circumſtances attending the *Aurora Borealis*, of which this was certainly a Species. For the Night following, a Neighbour gave me notice of a ſtrange ſtreaming of Lights ſeen in the Air, which thereupon I attended from the Hours of 9½ to 11, when a Fog came ſo thick as to put an End to my Proſpect. But during that whole Time there aſcended out of the E. N. E. and N. E. a continu'd Succeſſion of whitiſh *Striæ*, ariſing from below; and after changing, as 'twere, into a ſort of luminous Smoak, paſs'd over Head with an incredible Swiftneſs, not inferior to that of Lightning; and as it paſs'd, in ſome Part of its Paſſage, ſeem'd, as 'twere, gilded, or rather, as if the Smoak had been ſtrongly illuminated by a Blaze of Fire below. Some of the *Striæ* would begin high in the Air, and a whole Set of them ſubordinate to one another, like Organ Pipes, would preſent themſelves with more Rapidity than if a Curtain had been drawn from before them; ſome of which would die away where they firſt appear'd, and others change into a luminous Smoak, and paſs on to the Weſtwards with an immenſe Swiftneſs. And I am of Opinion, that had it not been for the Moon, then ten Days old and very bright, this for the Time would have been reckon'd as conſiderable an Appearance as that of the *6th* of *March*, 1716.

2.] On

— *the ſame in* Devonſhire, *by Mr.* W. Maunder, *ib.* p. 1101.

2.] On the 26*th* of *October*, between Seven and Eight in the Evening, I ſaw ſome ſmall Appearance of an *Aurora Borealis*, viz. three or four large Coruſcations in form of Pyramids, of reddiſh Colour inclining to yellow, which roſe about 50 Degrees above the Horizon, and continued but few Minutes. But the North Part of the Hemiſphere was very bright and red all the Evening both before and after, till ten, if not longer.

November 10. Theſe Lights were ſeen again about four in the Morning, of which ſome ſay, that the Element open'd ſometime at one Place, then at another; from whence came great ſhining Lights that continu'd a while, and then went away by Degrees, and the Holes cloſed up again. This continu'd till Day-break.

The Evening following, coming from *Tiverton* about half an Hour after Eight, I ſaw the North Part of the Horizon very light and reddiſh (notwithſtanding the Moon being about ten Days old, was then in or paſt the Meridian, and ſhone very bright.) In a ſhort Time the ſtreaming luminous Rays began to appear very plain; ſome in one Shape, ſome another; many of them like Cones or Pyramids, but moſt of them badly terminated; ſome of which mounted very high, almoſt to the Zenith, to which Place, or near, they all or moſt ſeem'd to point. Shortly after there appear'd a long Streak of about 30 Degrees parallel to the Horizon and about 15 or 20 diſtant from it, and about two or three broad, but badly terminated, and of a fiery red Colour: Which ſent out ſome of the ſame ſtreaming Beams towards the Zenith. About ſix or ſeven Minutes after, there appear'd (ſomewhat ſudden) a circular Figure like an *Iris*, but twice as broad, of a pale Colour. The Eaſt Part was terminated by the Horizon at full Eaſt, if not ſomething to the South, and the Weſt End about North Weſt; the upper Part of its Arch being 59 or 60 Degrees high, great Numbers of luminous Rays darted from it upwards and downwards, (or elſe paſſing croſs it from the Horizon) at oblique Angles pointing to the Zenith, eſpecially from the North Eaſt Part. This continu'd, as near as I can gueſs, about eight or nine Minutes, when it divided and diſappear'd. After an Interval of three or four Minutes, another *Iris*-like Figure appear'd, (of a Colour, as it ſeem'd, paler than any of the ſtreaming Lights had been) whoſe Diameter was leſs than that of the former, and ſhew'd more than its Semicircle above the Horizon, the upper Part of its Arch approaching near the Zenith. I could not obſerve any Rays to paſs from, (or a-croſs) this, as from the other. The Center of this laſt was much more to the Weſt, than that of the firſt. After the Continuance of a Minute or two, it began to break in the upper Part of its Arch; and ſhining Particles being ſent out from both its broken Ends towards the Zenith, (to which they were near before) or rather a little beyond it to the South or South-Weſt, they there formed a ſort of *Corona*, curving and bending ſomewhat like Flames reverberated on the Arch of an Oven: Tho' this expreſſeth it but badly, yet I know not how to deſcribe it better. It ſeem'd to me and others to be finely tinged with various Colours, Red, Yellow and Blueiſh, *&c.* and ſent out every way from it (except South and South-Weſt) long Flame-colour'd Rays. After this had continu'd about two Minutes, its ſhining Light abated, and it left behind it for ſome Minutes, ſomething like a whitiſh Cloud (like in Colour to what the Light on the 19th of *March* laſt left behind it, after the fiery Particles were extinguiſh'd, but thinner).

All this while the Moon ſhone very bright, from which this *Corona* was not very far diſtant, perhaps not twenty Degrees, to the North-Eaſt. After this there continu'd to be ſent up many fiery-colour'd or yellowiſh ſtreaming Lights, ſometimes more, ſometimes leſs; now here, now there, all along the North Part of the Hemiſphere, but moſtly from the North-North-Eaſt. All this while ſomething like ſmall whitiſh Clouds (which, to me, ſeem'd to move towards the Zenith, or to point a little more Southward, but diſappear'd as they approach'd the Moon) were carry'd very ſwiftly, and at very ſhort Intervals, moſtly coming from the Eaſt and North-Eaſt, but many alſo from North and North-Weſt. We took but little Notice of this at firſt, ſuppoſing it had been nothing but the Reflection of the other Lights, or the Shadows of the Clouds (whereof the North Parts were pretty full) as the Streams of Light paſs'd behind them: But at laſt, we obſerv'd, that when the Lights at any Time abated, theſe kinds of Clouds continu'd to fly as ſwift and frequent as ever. This I ſaw till Twelve or One next Morning: Many others ſaw it next Morning till almoſt Break of Day, when it appear'd much more red and fiery than it was in the Evening; the Moon perhaps being then ſet. Some People obſerv'd tall Cones to ariſe in the Eaſt, and to be carry'd to the Weſt pretty ſwiftly in an erect Poſition, but I ſaw them not. It has been repreſented here in all ſorts of Appearances, Armies, Battles, *&c.*

—the ſame at Dublin, *by—* ibid. p. 1104.

3.] On the 10*th* of *November*, the Afternoon having been very calm and ſerene, about Six in the Evening the Sky was tinged with a ſtrange kind of Light, and ſome Streams began to project from the North and N. E. One of them aroſe about N. by E. and was nearly a Subtenſe of an Arc between that and S. W. by Weſt; it was a little curvated toward the Sun, and what I ſaw of it (for the North Part of the Horizon was conceal'd by Houſes) very much reſembled the Tail of a Comet: About the ſame Time there was one or two which aroſe in the Eaſt, aſcending obliquely ſo as to leave the Zenith ſeveral Degrees to the Northward.

Theſe *Striæ* continu'd to appear and diſappear alternately, till toward Eight in the Evening; they were *Pyramidal*, and their *Vertices* frequently projected ſeveral Degrees to the South of our Zenith.

Between Nine and Ten, I was agreeably ſurpriz'd with a kind of Coruſcation, or Flaſhing, that ſhew'd itſelf between twenty and ſixty Degrees from the Zenith, in the South or South by Weſt; and which from four or five, ſometimes from more Places at once, darting with a Velocity not much inferior to that of Lightning; and by interfering with each other produced a beautiful Tremor or Undulation in that ſubtile Vapour, which I cannot better illuſtrate, than by comparing it to the Beams of the Sun, reflected on a Cieling from the Surfaces of two or three Baſons of Water: Theſe *Waves* of Light were only viſible at the Inſtant of Coruſcation, and were of a pale whitiſh Colour, ſomewhat reſembling the Flaſhes produced by the violent Agitation of Quickſilver in an exhauſted Receiver; but ſo ſtrong, that a Gentleman, who was in a Room by himſelf without a Candle, aſſur'd me, he took it for common Lightning: Thus it continu'd inceſſantly for more than an Hour, during which Time ſeveral lucid *Areas*, like little Clouds, diſcover'd themſelves in the pure Sky, and after they had continu'd about five or ſix Minutes, as near as I could gueſs, would inſtantaneouſly diſappear; moſt of them pretty much reſembled a very thin white Smoak or Vapour illuminated by the Full Moon.

About three quarters paſt Ten, this Vapour was almoſt ſpent, or by a briſk Gale at South by Weſt diſpers'd and driven to the Northward; at which Time, between the Weſt and North, a vaſt Body of it, like a very bright Flame-colour'd *Crepuſculum*, ſeem'd to be fix'd: From this Baſis ſeveral Beams or *Striæ* of ſhining Matter were at uncertain Intervals, emitted; and though it was not ſo ſenſible to the Eaſtward of the North, yet ſeveral mighty Pillars were alſo ejected from thence; one, which, if I miſtake not, aroſe directly under the Pole, was above all others that had preceded it, both as to its Magnitude and Denſity ſo ſurprizing, that I am perſuaded the ſmalleſt Print might have been read by the Light thereof, had not that of the Moon, which ſhone very bright, pretty much effac'd it: 'Twas tinged with a kind of Yellow and Violet Colour. In about two or three Minutes it died away, and was ſucceeded by others of an inferior Order: It was now about a quarter paſt eleven of the Clock, and nothing but repeated *Phaſes* of the ſame Spectacle offering themſelves to view; the vibrating Motion had ceas'd; the Vapour ſhew'd itſelf no longer in lucid *Areas*, the Streams of Light were not ſo frequent, and thoſe more languid than before; and the bright *Aurora* having ſettled nearer the Horizon, I concluded the Scene was at an End, and accordingly gave over the queſt of new *Phænomena*, with only obſerving, that about N. E. there appear'd ſome Clouds that reflected an unuſual kind of reddiſh Light. Others, who ſat up longer than I did, repreſent the End with very ſurprizing Circumſtances.

On *Tueſday* the 24*th* of *November*, we had the ſame *Phænomena* repeated, though not with the ſame Variety: About a Quarter paſt Ten at Night, a vaſt Body of ſhining Matter was collected between N. W. *by* W. and N. *by* E. in the Form of the Segment of a Circle, whoſe Center was about 25 or 30 Degrees below the Horizon; from its *Periphery* a few ſhort *Pyramidal* Streams, of the ſame luminous Vapour, aſcended by a ſlow and nearly uniform Motion, and were exceeding rare, ſo as not to efface the ſmalleſt of the Fix'd Stars; and in a Minute or two vaniſh'd: The Light which that Collection of Vapour emitted, was ſo great, that in the otherwiſe very dark Night, I could thereby (at three Quarters paſt Ten) read the Title of the laſt *Philoſ. Tranſact.* which then happen'd to lie on my Deſk; and at four or five Yards diſtance, ſee the ſmalleſt Books in my Study. *—— a return of the* ſame.

XXX. At *Streatham* in *Surrey*, on *December* the 11*th*, about one a Clock at Night (or rather in the Morning of *Dec.* the 12*th*) I was call'd to obſerve Coruſcations which appear'd of a much different Colour, and in a very different Manner, from any I had before ſeen. *An* Aurora Borealis *in* Surrey, *by Mr.* T. Hearne, n. 363. p. 1107.

The Streams of Light that darted upwards from the Horizon, ſeem'd to be at conſiderably a greater Diſtance, but not at all in leſs Quantity than thoſe of *Nov.* 10. But their meeting in a Point near the Zenith, and there forming a kind of Canopy, was what was particularly remarkable in theſe Coruſcations.

The Streams of Light roſe from the Horizon only towards the North, and on each Hand towards North-Eaſt and North-Weſt: But near the Zenith a Canopy was form'd of Streams of Light meeting in a Point, not only from thoſe Quarters, but alſo from the South, &c. Only to thoſe Points they extended downwards from the Zenith but a little Way, and were neither in ſo great Quantity, nor quite ſo bright as thoſe Northwards. At firſt I thought the Point in which the Streams met, was exactly the Zenith, but upon obſerving it ſomething longer, I found it was not ſo, but a few Degrees to the South of the Zenith. The Streams of Light near the Zenith, which form'd this Canopy, were of a pretty bright Colour, and in great Quantity, and darted very ſwiftly.

On each Side of the North, towards E. and W. but not exactly in the N. it ſelf (at leaſt when I ſaw it) from about 10 or 15 *gr.* to 40 or 50 *gr.* above the Horizon, the Streams were of a glowing red Colour, whereas all that I had ever ſeen before, were very pale. The Redneſs was like that of a burnt Brick, and neareſt of any Thing I have ſeen to the Colour, which remain'd for a few Minutes, like that Tract through which the Meteor paſs'd in the Spring.

The Streams appear'd of this fierce Colour when I firſt ſaw the Coruſcations, and continu'd ſo for ſome Time, till the Redneſs by degrees wearing off, in about ¼ of an Hour, they appeared of the uſual Paleneſs, when I left them ſtill forming a Canopy near the *Zenith*.

The Air was very calm and ſerene, not a Breath of Wind ſtirring; as I remember it was alſo, *Nov.* 10.

The Moon was now a Day or two older than it was on *Nov.* 10. and a good deal farther to the Weſt, than when I ſaw the Coruſcations that Night being full South. She had now round her what is commonly call'd a Burr, larger than ordinary, and ſeveral very lucid Clouds at a little Diſtance.

Northern Aurora's *ſeen abroad*, &c. *by Dr*. T. Robinſon, n. 349. p. 483.

XXXI. I am of Dr. *Halley*'s Opinion, that thoſe Phoſphorous or Luminous Appearances in the Firmament, proceed from the various *Effluvia* perſpir'd out of our Globe, or paſſing through it; for I have ſeen thoſe Lights over *Veſuvius*, the *Strombulo* Iſlands, and towards *Ætna*, in dark Nights, when thoſe *Vulcano's* were not flaming nor burning, their Sides and Tops being paſſable to Travellers at that Time, and all their outward Parts quiet. We are certain that *Iceland* and *Greenland* abound with *Vulcano's*; ſo may North-Eaſt *Lapland*, North *Ruſſia*, and *Tartary*, where vaſt Chains of Mountains are ſaid to run. The *Jeſuits*, and other Travellers, relate many prodigious Eruptions of Fires, and Earthquakes, towards the North of *China*; but nearer the Pole, the Earth muſt be cloſ'd and pent up many Months, by the long ſevere Freezings and continual Snow and Ice, which relaxing towards Spring, may give vent to that vaſt Maſs or Magazine of perſpirable Matter, that had been kept ſo long in hot Subterraneous Priſons. This may be one Reaſon why Animal Bodies themſelves are often ſenſible of Changes at that Seaſon in our Climate, when Perſpiration is upon ſuch an Increaſe.

Experiments on the Motion *of* Pendulums *in* Vacuo, *by Mr*. W. Derham. n. 294. p. 1785.

XXXII. Deſiring to know what Difference there might be between the *Vibration of Pendulums in Vacuo*, and in common *Air*, I recommended the Experiment to Mr. *Hawkſbee*, who having provided himſelf with a proper Receiver, and all other Things neceſſary, with a Friend of mine in *London*, made the Experiment. The Movements he tried with were an Eight-Day Clock vibrating Seconds, and an half Seconds Movement of mine. The Iſſue of their Experiment was, my Pendulum vibrated two Tenths of an Inch on each Side farther in *Vacuo*, than it did in the free Air, and went ſeven Seconds ſlower in twenty Minutes, than the other Movement.

But in the open Air, my Pendulum in twenty Minutes, went only $3\frac{1}{3}$ Seconds ſlower than the other Pendulum.

This Experiment I try'd over myſelf; the Inſtruments I made uſe of, were, firſt, an *Air-Pump* of Mr. *Hawkſbee*'s.

The next was a *Small Movement*, with a Pendulum of about ten Inches, that vibrates *Half-ſeconds*, and is driven by the Power of a Spring. This Inſtrument I thought commodious, not only for being eaſily fitted with a Receiver, but alſo for vibrating Half-ſeconds very nicely, and alſo becauſe its Vibrations are equal, not ſome large, ſome ſhorter.

The laſt Inſtrument was a very well regulated *Month-Piece*, that vibrates *Seconds* all the Year, with as much Exactneſs as moſt do.

Being thus furniſh'd, the Reſult of many repeated Experiments, Day after Day, was, That (as before) in *Vacuo* the Vibrations were always larger than in the Receiver unexhauſted. At the firſt, when my little Movement was newly clean'd, the Vibrations were above $\frac{3}{10}$ of an Inch larger than in the free Air. But afterwards (I ſuppoſe, from ſome of the foul'd Oil of the Pump ſpirtled on the Wheels, in letting in the Air, whereby the Force of the Spring on the Pallets was blunted, from hence, I ſay) as the Vibrations in the unexhauſted Receiver were a little contracted, ſo in the Receiver exhauſted, they were more contracted, and only about o, 25 of an Inch larger than in the free Air.

The *Alteration* in *Time*, which this Difference of the Vibrations produc'd, was conſtantly only about two Seconds in an Hour ſlower, in the Receiver exhauſted, than in it unexhauſted. For if in four, five, or more Hours going, the two Pendulums did not vary a Quarter of a Second in the open Air, or when the Receiver was put over the little Movement, (but unexhauſted); yet when the Receiver was exhauſted, the Half-ſeconds Movement would loſe, at the Rate of two Seconds in every Hour, in every Experiment, in many Hours going.

And becauſe I had a Mind to ſee what Alterations would ariſe from varying the Vibrations, therefore by opening and ſhutting the Pallets, I cauſed the Vibrations in ſome Experiments to be as large as the Receiver would bear; in others, to be as ſhort as poſſible; always adjuſting the Pendulum to vibrate Half-ſeconds nicely in the Air. But ſtill the Succeſs was much the ſame, or the Difference ſcarce perceptible. But only I imagin'd when the Pendulum vibrated but a little Way from the Perpendicular, that the Vibrations in *Vacuo* were not ſo much enlarged, as when it vibrated in a larger Arch.

In all theſe Experiments (which were repeated divers Times with the ſame Succeſs) I had no other Reaſon to move me to think, but that the Vibrations were enlarg'd in *Vacuo* by the vaſt Rarefaction of the *Medium*, but this, That perhaps the different State of the Air might alter the Force of the Spring, which drove the Movement. For the Trial of this, I put a well-adjuſted *Pocket-Watch* (with *Hook*'s Regulator, *i. e.* the common ſmall ſpiral Spring to the Balance) into the *Vacuum*; and after ſeveral Trials, at the ſame Pitch of the Spring, I found not the leaſt Alteration in the Watch's going, in many Hours; neither the Springs, nor any other Part of the Watch, ſeeming to be in the leaſt affected by the *Vacuum*: But the Balance circumvolving, or keeping the ſame Turns, as in the open Air.

I then try'd what the Succeſs would be, by putting the Half-ſeconds Pendulum again into the Receiver, and only pumping out a Part of the Air. And accordingly I left no more Air in, than what kept the included Mercurial Gage at about ſix Inches Height; the Event of which was, that the Vibrations were then not above $\frac{1}{10}$ of an Inch larger on each Side, than in the Receiver unexhauſted: And the Time loſt but about Half a Second in an Hour, or $\frac{1}{6}$ at moſt. And ſo, according as the Mercurial Gage was more or leſs high, I always found the Vibrations greater or leſs; they gradually decreaſing, according to the Quantity of Air re-admitted. From theſe Experiments we may remark,

1. What Mr. *Boyle* long ſince obſerv'd (from a cock'd Piſtol going down as fiercely in his *Vacuum*, as in the Air) may be hereby farther confirm'd, *viz.* That the Air is not the Cauſe of the Motion or Reſtitution in Solid Bodies, as Springs. For if it was, it would certainly have been diſcover'd in ſo tender an Inſtrument as a well-adjuſted Pocket-Watch, lying under the perpetual Influence of two Springs.

2. As in *Vacuo* (where the Preſſure of the Atmoſphere is taken off) heavy Bodies deſcend quicker than they do in the open Air; ſo it may be obſerv'd, that Pendulums move ſwifter in the Receiver exhauſted, than in it unexhauſted.

That heavy Bodies deſcend quicker in *Vacuo*, is evident, from the ſwift Deſcent of the leſs heavy Bodies, as *Cork*, the *Down of Sowthiſtles*, the *lighteſt Feather*, &c. which do all precipitantly deſcend, like a Stone, in a tall exhauſted Receiver.

And that the Pendulum, in our Experiment, mov'd faſter in *Vacuo*, is manifeſt, from its vibrating but two Seconds in an Hour ſlower, when the Vibrations were $\frac{1}{3}$ of an Inch on a Side, enlarg'd by the higheſt Rarefaction of the Air. Whereas I find by Experiment, that near the ſame Increaſe of the Vibrations, doth, in the open Air, make the Pendulum go ſix or more Seconds ſlower in an Hour. I ſay, *near the ſame Increaſe*, becauſe it is ſcarce poſſible to manage the Pallets ſo, as nicely to make the ſame Vibrations as were in *Vacuo*.

3. The laſt Thing I ſhall deduce ſhall be by way of Query, *viz.* Whether the Variations of Pendulums obſerv'd under the Equinoctial, and between the Tropics, do not ariſe as much or more from the Rarity of the *Medium*, and the Encreaſe of the Vibrations conſequent thereupon? It is ſcarce, I think, to be doubted, but that the Air is much thinner and finer near the Line, than it is without the Tropics. And it is evident from the Barometer, that on the Tops of high Mountains the Atmoſphere gravitates leſs than nearer the Center. And therefore (although I like the Notion of the Decreaſe of Gravity from the Encreaſe of the Diſtance from the Earth's Center too well to diſcard it, yet) I am apt to think that this is not the only Reaſon of the *Phænomenon*.

I wiſh that Capt. *Halley*, when he obſerv'd at St. *Helena* his Clocks to go ſlower than in *England*, had at the ſame time obſerv'd whether the Vibrations were not enlarg'd. It might be worth the while for ſuch as have Opportunity, to take Notice, whether their Pendulums between the Tropics do not make larger Arches than higher Latitudes? Alſo in what Latitude they begin to alter? Whether the Vibration be greater near the Line, than in any other Parts between the Tropics? Or, whether the greateſt Encreaſe be not always in thoſe Places where the Sun paſſeth their Zenith? If the Vibrations be found larger under the Line, or in any other Part of the Torrid Zone, then it may be obſerv'd, how much larger they are, and in what Proportion they encreaſe, or decreaſe, by approaching nearer unto, or receding from the Place of their greateſt Encreaſe?

Alſo it may be worth obſerving, Whether Pendulums do not vary on the Tops of high Places, or in different States of the Atmoſphere, according as the *Mercury* is high or low in the Barometer? But then in this, and indeed in the former Caſes, it is neceſſary, or at leaſt very expedient, that the Movement be ſo exactly well made, that the Power, whether Weight or Spring, do at all Times exert the very ſame Force upon the Pads or Pallets. For moſt Clocks are apt to vibrate ſometimes larger, ſometimes leſſer Arches in the 24 Hours, according as the Weight or Spring doth more or leſs exert its *Forces* on the Work.

An Experiment of firing Gun-powder *in* Vacuo, *by Mr.* F. Hawkſbee. n. 295. p. 1086.

XXXIII. 1.] A Candent Iron being included in a Recipient proper for that Purpoſe, and the Air withdrawn (which was in about two Minutes of Time) the *Mercury* then in the Gage ſtanding at 29 Inches $\frac{1}{2}$, a Quantity of Gun-powder was immediately made to deſcend upon the red hot Iron, which continu'd upon the Surface of it ſome ſmall Time before it went off, and then was obſerv'd not to fire all at once, and the laſt of the Quantity that did ſo ſeem'd to give the greateſt Flaſh; upon which the Mercurial

Gage was taken Notice of to deſcend ſomething more than an Inch, it riſing again ⅒ of the ſame: And upon ſeveral Repetitions of the like Quantity of Powder (the factitious Air being always withdrawn) the Appearances were very reſembling. Again upon purging the Recipient of the factitious Air, and the *Mercury* elevated in the Gage, as at firſt, three Quantities were cauſed to deſcend upon the Iron, whoſe Exploſion as well as the Air produc'd from them, ſeem'd in Proportion to the Quantity of Powder; the *Mercury* then in the Gage ſubſiding to 26. But upon dropping ſix Quantities (the Recipient being firſt purg'd as before) which Quantities not deſcending all at once, but ſucceſſively as faſt as might be, the Quantities that firſt reach'd the (ſtill Ignited) Iron taking Fire, by their Flame making an Exploſion of the whole, at once blowing up the Recipient, although the Weight of the Air incumbent on it was equal to 144 *l.* ½, accounting the Receiver at 3 Inches ½ Diameter, but was ſomething more, which does ſufficiently allow for the want of Height of *Mercury*. The Gage then ſtanding at 29 ½, inſtead of 30, from which the Calculation is made. The Gun-powder us'd was the common glaz'd ſort; and the Weight of the ſix Quantities, which remov'd the Recipient, with ſo great a Preſſure incumbent on it, was but ſeven Grains, each Quantity weighing ſomething more than one. I did not obſerve the Recipient to be broke before it reach'd the Floor. It was thick lin'd with Sulphureous and Nitrous Steams, ſo that the Flaſhes of Fire through the Cloudineſs of the Glaſs ſeem'd very much to reſemble faint Lightnings. The Content of the Receiver was equal to about 25 Ounces ½ of Water, allowing for the Bulk of Iron and Pedeſtal.

The Quality *of the* Air *produc'd by* Gun-powder, *by the* ſame, *ibid.* p. 1807.

2.] Upon making the late Experiment before the *Society*, of firing Gun-powder *in Vacuo*, it was hinted as well worthy of Trial, Whether the factitious Air of fir'd Gun-powder was endu'd with any Quality differing from common Air? In order to the Satisfaction of the Query, I included a Candent Iron *in Vacuo*, the *Mercury* then in the Gage ſtanding at 29 Inches ½: Upon dropping the firſt Quantity of Powder, (by a Quantity is to be underſtood ſomething more than a Grain weight) its Exploſion made a Deſcent of the *Mercury* in the Gage about an Inch, undulating very little. The ſecond Quantity being let fall, the *Mercury* ſubſided about ¾ of an Inch; and ſo for ſeveral Quantities following it deſcended by pretty equal Stages, till it had fallen about ſix or ſeven Inches; and it was obſerv'd, upon every Quantity fir'd, the Undulations of the *Mercury* increas'd. But after it had ſubſided ſix or ſeven Inches from 29 ½, the ſeveral Deſcents of it became leſs, very little or nothing exceeding ½ an Inch, although the Quantities firſt were equal; but ſtill the Undulations encreas'd, and the Exploſions manifeſtly did ſo too: 'Till at laſt the Receiver ſeem'd to be in great Danger of being blown up by a ſingle Quantity, the Undulations of the *Mercury* being then augmented to ſix or ſeven Inches. Now 26 Quantities of 32 Grains having been fir'd upon the Iron, and the *Mercury* in the Gage having fallen to 12¼, I diligently attended to obſerve the Gage, which in ſeven Minutes had aſcended 2 Inches ½, the next five Minutes it aroſe but 1 Inch ¼, and ſo leſs ſucceſſively every five Minutes, that in an Hour and 17 Minutes, it had attain'd but to 21 Inches, the Iron not being quite cold. At Nine the ſame Night I obſerv'd the Gage, and found the *Mercury* elevated to 22 Inches ¼ preciſely: Next Morning at Nine it had attained to 22½, and ſo continu'd all that Day, the Iron being then reduc'd to the Temperature of the outward Air. So that from 12¼ to 22½, ſeems to be the Weight or Spring of Heat equal to about ⅓ of an Atmoſphere of Air, which would preſs the *Mercury* upon the upper Part of the Gage, but equal to ſuch a Degree of Heat as was then contain'd in the Receiver, when the Gage was fallen to 12¼: The remaining Space from 22½ to 29½ is ſuppos'd to be ſupply'd with factitious Air, and anſwers to about ¼ Part of the Recipient's whole Content, which was equal to 25 Ounces ½ of common Water, allowing for the Iron and Pedeſtal. This Air produc'd from Gun-powder, I find to be actuated by Heat and Cold as common Air: For, holding my warm Hands upon the Receiver, the *Mercury* in the Gage would immediately deſcend, and riſe again when reduc'd to the Temperature of the outward Air. This I repeated ſeveral Times with the like Succeſs. What more occurs in this Experiment is, Why the Exploſions of the like Quantities of Gun-powder ſhould be greater when reſiſted by Air, than in *Vacuo*, where nothing ſeems to hinder the Extenſion of their Flame.

Deſcent of Malt Duſt *in* Vacuo, *by Mr.* F. Hawkſbee. n. 298. p. 1948.

XXXIV. I took ſome Malt Duſt, and having well dry'd the ſame, put a Quantity of it into a fine Muſlin Bag, where being looſely incloſ'd, it would, upon ſhaking, diſcover itſelf plentifully in the open Air, undulating and floating a conſiderable Time before it would deſcend; but being included within a Receiver, from which the Air was well exhauſted, and then ſhaken, the Duſt deſcended as a ponderous Body, precipitating in ſtraight Lines from the Top to the Bottom of a tall Receiver.

An Experiment *to prove an* Interſpers'd Vacuum, *by Dr.* J. T. Deſaguliers. n. 354. p. 717.

XXXV. Having had the Honour to make ſome Experiments laſt Year before *His Majeſty* and their *Royal Highneſſes the Prince and Princeſs of* Wales; among others, I ſhew'd that of a Guinea and a Piece of fine Paper; then of a Guinea and a Feather dropp'd together from the Top of an exhauſted Glaſs Receiver about 20

Inches high; both which fell to the Bottom at the ſame Inſtant of Time: Now ſince the chief Reſiſtance of a *Medium* (and indeed almoſt all of it) depends upon the (†) Quantity of its Matter; therefore this Diminution of Reſiſtance, whereby the Feather fell as ſoon as the Guinea, ſhew'd a Diminution of the Quantity of Matter, and conſequently prov'd an *interſpers'd Vacuum*. Some Time after this, I was inform'd, that ſome *Pleniſts* objected againſt the Shortneſs of the Glaſs-Receiver; as if the Difference of Time in the Fall of the two Bodies, which they affirm'd to be real, could not be perceiv'd in ſuch a Glaſs; and that ſome Philoſophers from abroad affirm'd, that in a Glaſs-Receiver ſeven or eight Feet long, there would be ſuch a manifeſt Difference in the Time of the ſaid Bodies, as to ſhew this Experiment no Proof of a *Vacuum*: To obviate this, I contrived a Machine for the Purpoſe, which conſiſted of a ſtrong Wooden Frame 15 Feet high, that held the Air-Pump and four Cylindric Glaſs-Receivers of about two Feet long each, and ſix Inches Diameter: Of theſe, having ſet the firſt upon the Air-Pump-Plate, I laid on the Top of it a Braſs-Plate of ſeven Inches Diameter, that had an oil'd Leather fix'd to it above and below, with an Hole through the Middle, of between four and five Inches Diameter; then on that Plate I ſet the next Receiver, with a like Plate at Top; and after the ſame Manner fix'd the other two with Plates between them: The upper Receiver being a little narrower at the Neck, went into the Hole of a Board, whereby it was ſcrew'd down pretty hard on the other Glaſſes, and fix'd to the whole Machine. On the Top of this upper Receiver, I had the Braſs Plate, wet Leather, and Braſs Springs which contain'd the Bodies to be dropp'd.

Having acquainted his Majeſty with what I had prepar'd, he order'd me to ſhew him the Experiment with this long compounded Receiver, at *Hampton-Court*; and when I made it before him and her Royal Highneſs, he was pleas'd (by pulling down a String fix'd to a Leaver at the Top of the Machine) to let looſe the Bodies himſelf.

When the Receiver was full of common Air before Pumping, the Guinea came to the Bottom, juſt as the Paper was about the Middle of the ſecond Glaſs; but when the Receiver was exhauſted, the Guinea and Paper came to the Bottom preciſely in the ſame Inſtant of Time.

Upon my giving an Account of the Succeſs of this Experiment to the *Royal Society*, they order'd me to repeat it before them on the *5th* of *December* 1717.

I made the Experiment firſt with two of the Receivers; then with all the four; dropping a Guinea and a ſmall Piece of Paper together; and the Succeſs anſwer'd Expectation: But not being

willing

(†) *See Sir* Iſ. Newton's *Principia*, Book II. Prop. 40.

willing to try with a Down Feather, becauſe I fear'd the Air might inſinuate between ſome of the Glaſſes, by reaſon the Number of Perſons preſent ſhak'd the Room, the Society order'd me to make the Experiment at Home, before one or more of their Members.

Martin Folkes, Eſq; was preſent when I made the Experiment at my Houſe, where we made four Trials in the following Manner:

The whole Machine being fix'd, as above mention'd, we firſt let fall a Guinea and two Papers, the one plac'd over, and the other under it, (before any Air was pump'd out) and the Guinea came to the Bottom when the Papers were only in the middle of the ſecond Glaſs from the Top. Then having laid a Feather on the Braſs-Springs cloſe by the Guinea, we let them looſe both together; and the Feather was fallen only down to the fourth Part of the Length of the firſt Glaſs, or one ſixteenth of the whole Diſtance, when the Guinea was got down to the Bottom of the Receiver. We then laid two Papers and two Feathers, one of each under, and the other over the Guinea between the Springs; and having drawn out ſo much of the Air as to bring up the *Mercury* in the Gage-Tube within a Quarter of an Inch of the greateſt Height to which it could be then rais'd by the Preſſure of the external Air, we caus'd the Bodies to fall all at once: And though the Papers came down to the Bottom at the ſame Time as the Guinea, yet the Feathers, being much lighter, wanted about three Inches. But at laſt, having laid the Papers, Feathers, and Guinea, as before, we pump'd out all the Air, and then the Feathers, as well as the Papers, came to the Bottom of the Receiver at the ſame Inſtant of Time as the Guinea.

Experiments *to find how much the* Reſiſtance *of the* Air *retards* Falling Bodies, *by Dr.* J. T. Deſaguliers. n. 362. p. 1071.

XXXVI. 1.] I took twelve Balls, (ſix of which were ſolid Leaden Globes, of about two Inches Diameter; three hollow Glaſs Balls of about five Inches Diameter; and three light Paſteboard hollow Globes of about the ſame Diameter) and having carried them to the upper Gallery in the Lanthorn, on the Dome of St. *Paul's* Church, I caus'd them to fall down by two at a Time, in the following Manner;

First, a Leaden Ball and a Glaſs Ball.
Secondly, a Leaden Ball and a Glaſs Ball.
Thirdly, a Leaden Ball and a Glaſs Ball.

Then I let fall, in the ſame Manner, the three other Leaden Balls, each with a Paſteboard Ball.

After that, having the Leaden and Paſteboard Balls brought up again, I repeated the Experiment twice more with a Leaden and Paſteboard Ball: Then I made the Experiment twice more with a Paſteboard Ball alone, to ſee how long it would be in falling.

Upon the whole, it appear'd, that the Leaden Balls were a very little longer than 4½ Seconds in falling; the two largeſt of the Glaſs Balls 6 Seconds, and the Paſteboard Balls 6½ Seconds.

The Height of the Gallery, from whence the Bodies fell, was 272 Foot above the Pavement of the Church (then cover'd with Boards) upon which they fell.

The Times of the Falls were taken two Ways above, *viz.* with a Wheel-Chronometer, which meaſures a ſmall Part of Time accurately, nearer than to a Quarter of a Second, (made and contriv'd by Mr. *Graham*) and with an ½ Second Pendulum; And the Differences of Time between the Fall of the Leaden Balls, and the other Balls, were taken below, by Sir *Iſaac Newton*, *Martin Folkes*, Eſq; and another Perſon, who all agreed in their Obſervations of the Time, which they made each with an half Second Pendulum.

The following Table gives the Marks, Weights, and Diameters, of the ſeveral Balls, in three Columns.

Leaden Balls.	*Troy Weight.* *l.* *oz.* *d.*	*Diameters in Inches and Decimals.*
1 *c*	2 : 1 : 0½	2, 1
2 *c*	1 : 11 : 4	1, 99
3 *c*	1 : 11 : 12	2, 0
4 *c*	1 : 11 : 12	2, 0
5 *c*	1 : 11 : 12	2, 0
6 *c*	1 : 10 : 00	1, 98
Paſteboard Balls.		
A	0 : 3 : 6	5, 5
B	0 : 1 : 14	5, 1
C	0 : 1 : 17	5, 1
Glaſs Balls.		
D	0 : 3 : 13½	3, 9
E	0 : 5 : 3½	5, 42
F	0 : 6 : 0½	5, 55

N. B. The Polar and Equatorial Diameters of the Glaſs Balls being different, I have ſet down a mean Diameter for each of 'em; the true Diameters are thus, of D 4 and 3,8. of E 5,6 and 5,25. of F 5,7 and 5,4 Inches.

The particular Experiments are as follows.

Exp. I. Fall of 1 *c* and D. *c* fell by the Pendulum in 4½″.
The Fall of D was ſo near it, that the Difference was not taken either above or below.

Exp. II. Fall of 2 *c* and E.

2 *c* fell by the Chronometer in 5″, by the Pendulum in 4½″. Time of the Fall of E not taken above. The Difference taken below 1¾″.

Exp. III. Fall of 3 *c* and F.

3 *c* fell by Chronometer in 4¾″, by the Pendulum in 4½″. F fell in ſix Seconds. The Difference taken below, was 1½″.

Exp. IV. Fall of 4 *c* and A.

4 *c* fell by Chronometer in 4¾, by the Pendulum in 4½. A fell in 6½ Seconds. Difference taken below = 2″.

Exp. V. Fall of 5 *c* and B.

We made no Obſervation above nor below.

Exp. VI. Fall of 6 *c* and C.

6 *c* fell by Chronometer in 4¾″, by the Pendulum in 4¾″. C not taken above. Difference below = 2¼″.

Exp. VII. Fall of 1 *c* and B.

1 *c* fell by Chronometer in 4¾″, by the Pendulum in 4¾″. B not taken above. Difference taken below 2¾″.

Exp. VIII. Fall of 5 *c* and A.

5 *c* fell by the Pendulum in 4¾″. A fell foul, and ſo was not obſerv'd at all. Difference taken below 2″.

Exp. IX. Fall of B alone.

By the Chronometer in 6¼″, by the Pendulum in 6½″.

Exp. X. Fall of C alone.

By the Chronometer in 6½″, by the Pendulum in 6½″.

By *Galileo*'s Theory, the Lead, which was 4½″ in falling, muſt fall four Foot the firſt ½″; or ſixteen Feet the firſt Second, which amounts to 324 Foot in 4½″. But as the Sound of the Ball (as it ſtruck the Bottom) by which we reckon'd our Time, had 272 Feet to move, we muſt abate a ¼ of a Second nearly, (ſuppoſing Sound to move one Mile in 4½″) which will take away 35 Feet, that the Body muſt have fallen in the laſt ¼ of a Second, and reduce the Number of Feet to 289: So that the Lead will have only fallen 17 Feet ſhort of the Theory, which muſt be attributed to the Reſiſtance of the Air.

The large Glaſs Ball in the 6 Seconds of its Fall, would in a *Vacuum* go through 576 Feet: But taking away the laſt ¼ of a Second 47 Feet, for Motion of Sound, it muſt only fall 529 Feet in *Vacuo.* Now ſince it fell but 272, there have been 257 Feet taken off from the Fall by the Air's Reſiſtance.

Likewiſe the Paſteboard Ball in 6½ Seconds muſt have fallen 676 Feet: But deducting the laſt Quarter of a Second, or 51 Feet, for the Motion of the Sound, there remains only 625 Feet for its Fall in *Vacuo.* But as it fell only 272 Feet, we muſt allow a Retardment of 353 Feet for the Reſiſtance of the Air.

At a Mean we may call the Weight of the Glaſs Ball five *Oz. Troy*, and its Diameter 5 Inches and $\frac{1}{5}$; and the Weight of the Paſteboard Ball two Ounces *Troy*, and a little more than five Inches Diameter.

The Lead Balls all fell within near a Foot of one another, and made an Impreſſion in the Boards of about $\frac{1}{5}$ of their Depth.

The Barometer ſtood at 30,1 Inches, and the *Mercury* was very convex, and therefore inclin'd to riſe ſtill.

Some further Experiments *on the* ſame, *by the* ſame, *ibid.* p. 1075.

2.] Having found by our former Experiments, that thin Glaſs Balls, and even Balls of paſted Paper, were too heavy to make ſo conſiderable a Difference between the Time of their Fall and the Fall of Leaden Balls, that it might be eaſily obſerv'd; I contriv'd a Way to make dry'd Hogs Bladders perfectly round, by blowing them (when moiſt) within a ſtrong ſpherical Box of *Lignum Vitæ*, and letting them dry in the ſaid Box before I took them out: Which I did by opening the Box that ſcrew'd in the Middle, and had a Hole in the Pole of one of its Hemiſpheres to let the Bladder paſs through, in order to tie it after blowing; and ſome few ſmall Holes all over the Box, that, in blowing, no Air might be confin'd between the inſide of the Box and the Bladder, ſo as to hinder it from putting on a ſpherical Figure. Beſides, I took off the Ends of the *Ureters*, the Fat, and a great deal of the upper Coats of the Bladders, before I blow'd them in the Box, to render them ſtill lighter.

The Bladders I us'd, were ſome of the thinneſt I could find ready blown at a *Druggiſt*'s, which I moiſten'd in Water, taking Care to leave none in the inſide.

Having prepar'd five Bladders in the Manner aforeſaid, I took them up to the upper Gallery in the Lanthorn on the Top of the *Cupola* in St. *Paul*'s Church; and there, by a Contrivance which I ſhall deſcribe, I let them fall by one at a Time, together with a Leaden Ball of about two Inches Diameter, and weighing 2*l. Troy*: And I took Notice of the Time of the Fall of each Bladder, knowing by former Experiments that the Balls are about 4$\frac{1}{4}$ Seconds, or a little longer Time, in falling the ſame Height, which is 272 Feet.

The following Table, conſiſting of five Columns, gives in the firſt, the Marks of the Bladders; in the next their Diameters; in the third their Weights, in Grains *Troy*; in the fourth the Times of their Fall in Second Minutes of Time; and in the fifth, the Difference of Time between the Falls of the Leads and of each Bladder; taken below by Sir *Iſ. Newton*, Dr. *Halley*, Dr. *Jurin*, *Martin Folkes*, Eſq; and Mr. *Graham* the Clock-maker. The Time was taken above with Mr. *Graham*'s Chronometer; and below with the ſame Inſtrument,

ment, and three half Second Pendulums, all which agreed very well together.

The Experiments having been made twice over, the Table is twice ſet down; and thoſe Experiments in which the Bladders fell ſtraight down, and the moſt regularly, have this Mark before them (*).

Marks.	*Diameters in Inches.*	*Weight in Grains Troy*	*Time of the whole Fall.*	*Diff. between the Lead and Bladder.*
A	5, 3	128	$19\frac{3}{8}''$	$14\frac{3}{8}$ Seconds.
* B	5, 193	156	$17\frac{1}{4}$	$12\frac{1}{4}$
C	5, 33	$137\frac{1}{2}$	$18\frac{3}{4}$	$14\frac{5}{8}$
D	5, 26	$97\frac{1}{2}$	$22\frac{1}{8}$	$17\frac{6}{8}$
* E	5, 02	$99\frac{1}{8}$	$21\frac{5}{8}$	17
* A			$19''$	$14\frac{1}{2}$
B			$18\frac{5}{8}$	$14\frac{1}{4}$
* C			$18\frac{3}{8}$	14
D			24	$19\frac{1}{8}$
E			$21\frac{1}{4}$	$16\frac{6}{8}$

The Diameters and Weights may be rely'd upon, being taken the Day that the Experiments were made, and the Day after; but the Diameters and Weights taken ten Days before, not agreeing with theſe, I have left them out. For the Bladders by drying had loſt their Weight, and alter'd their Diameters.

As the Necks of the Bladders in drying ſhrink, ſo as to open a little, they muſt be blown before each Experiment. And for the Manner of letting them fall exactly in the ſame Inſtant of Time, it is deſcrib'd by *Figure* 25, in which

A, A, A, A, is the Hole through which the Bodies fell: 1, 2, is a Board laid over the Hole. G, D, D is another Board fix'd to the firſt Board by the two Wood-Screws D, D with a Pulley G at the other End of it, over the Hole. W, is a two Pound Ball of Lead faſten'd to a ſtrong Thread, which going over the Pulley, is ſtretch'd horizontally from G to the Nails F; to which it is faſten'd, ſo as to be about a quarter of an Inch above the Board. Fig. 25.

B is one of the Bladders, hanging with the Neck or heavieſt Part downwards, by Means of a Loop of fine Thread as E H, which goes over the Horizontal Thread G E F. Now when with a Pair of Sciſſars the Thread of the Lead (which in all is but one Foot long) is cut juſt at E, before the Loop of the Bladder, the Lead pulling away the String, the Loop of the Bladder ſlips off the remaining Thread F E, and begins to fall exactly in the ſame Inſtant as the Lead: But if the Thread ſhould be cut between E and

F, as the Lead falls, its Thread might give the Bladder an oblique Direction.

He that obſerves the Time either with a Pendulum or Chronometer may take it very exactly, by ſeeing the Motion of the Sciſſars as they cut the Thread.

N. B. As the Diameters of the Bladders were taken by wrapping a Thread twice round them, and ſomething muſt be allow'd for the Thickneſs of the Thread; I have here under ſet down the Diameters of the Bladders, as corrected by that Allowance. *Viz.* A 5, 28 Inches; B 5, 19; C 5, 30; D 5¼; and E juſt 5 Inches in Diameter.

The Bladder E was rough, with ſeveral Wrinkles and Inequalities, which made it be longer in falling than it ought to have been, according to its Diameter and Weight.

A Pail of Water thrown down met with ſuch a Reſiſtance in falling 272 Feet through the Air, that it was all turn'd into Drops like Rain.

XXXVII. *Papers,* &c. *of Mr.* Hawkſbee's *Omitted.*

n. 303. p. 2129. 1. An Account of ſeveral *Experiments* on the *Mercurial Phoſphorus,* made before the *Royal Society.*

n. 304. p. 2165. 2. An Account of ſeveral *Experiments* made before the *Royal Society,* concerning the *Attrition* of *Bodies* in various *Mediums.*——Of *Amber* on *Woollen* in *Vacuo.*— Of *Flint* on *Steel* in *Vacuo.*— Of *Glaſs,* and various other Bodies in *Vacuo.*— Of *Glaſs* on *Woollen*——of *Glaſs* on *Oyſter-Shells* — of *Oyſter-Shells* on *Woollen* — of *Woollen* on *Woollen* —of *Glaſs* on *Glaſs*—of *Glaſs* on *Glaſs* under *Water.*

n. 307. p. 2277. 3. An *Experiment* concerning the Production of *Light* on a ſlight *Attrition* of the *Hands* on a *Glaſs Globe* exhauſted of its *Air,* &c.

n. 308. p. 2327. 4. An *Experiment* concerning the *Electricity* of *Glaſs,* produc'd by a ſmart *Attrition* of it.

Ibid. p. 2332. 5. A Continuation of the *Experiments* of the *Attrition* on *Glaſs.*

n. 309. p. 2372. 6. Some further *Experiments* relating to the *Electricity* of *Glaſs,* and of the *Effects* of the *Effluvia,* &c.

n. 310. p. 2313. 7. An *Experiment* confirming a former one, concerning the Production of *Light* by the *Effluvia* of one *Glaſs* falling on *another* in Motion.

Ibid. p. 2415. 8. An *Experiment* ſhewing the Difficulty of *Separating* two *Hemiſpheres,* upon the injecting of an Atmoſphere of *Air* on their *Outward Surfaces,* without *exhauſting* the included *Air.*

n. 305. p. 2221. 9. An *Experiment* concerning the *Proportion* of the Weight of *Air,* to the Weight of an equal Bulk of *Water,* without *knowing* the abſolute *Quantity* of either.

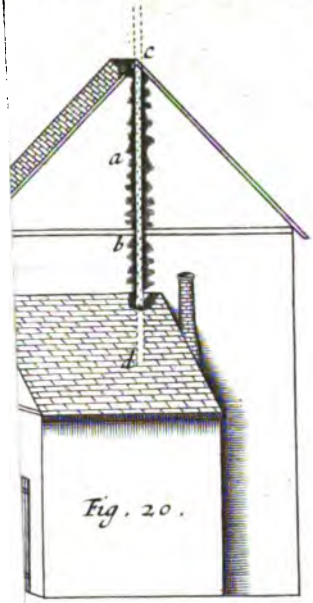


Fig. 20.

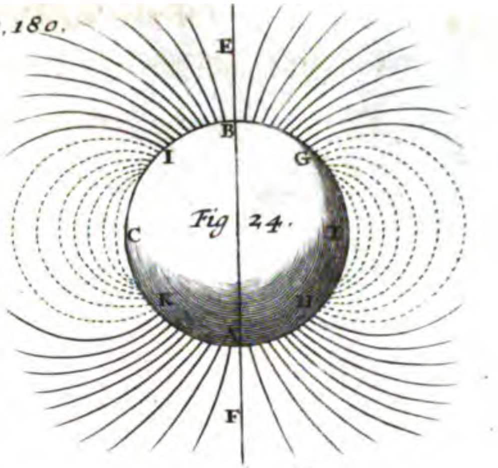


Fig 24.

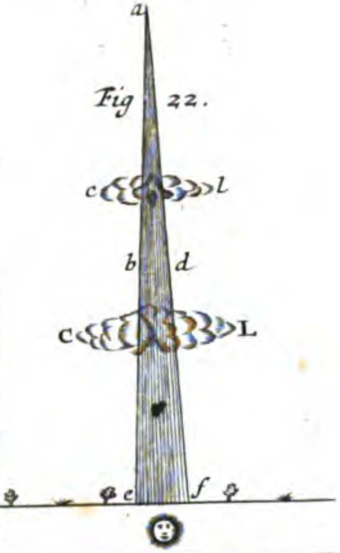
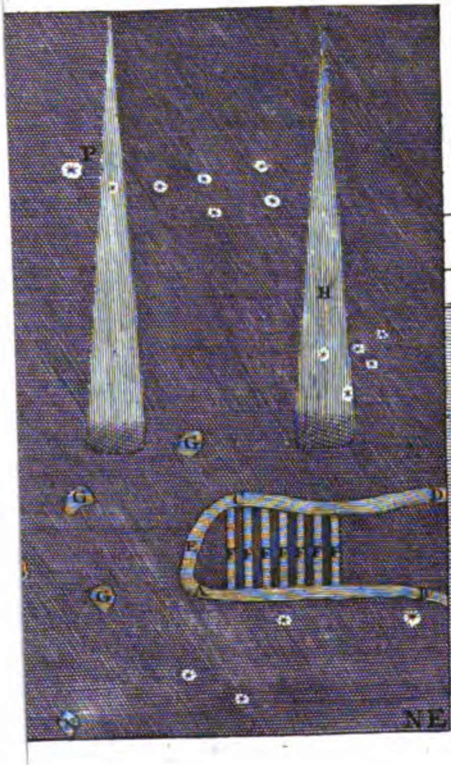


Fig 22.



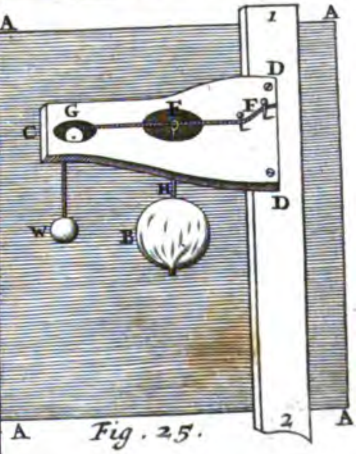


Fig. 25.

10. An *Experiment* ſhewing, that the *Aſcent* of *Liquids* in *Small Tubes* open at both Ends, is the ſame in *Vacuo* as in the open *Air*. *Ibid.* p. 2223.

11. An *Experiment* concerning the *Quantity* of *Air* produc'd from a certain *Quantity* of *Gun-powder* fir'd in common Air. n. 311. p. 2409.

12. An *Experiment* ſhewing, that the *Springs*, or conſtituent Parts of *Air* are capable of ſuffering ſuch *Diſorder* by a violent *Impulſe*, as to require Time to recover their Natural State. *Ibid.* p. 241[illegible].

13. An *Experiment*, ſhewing the *Cauſe* of the *Deſcent* of the *Mercury* in the *Barometer* in a *Storm*. n. 292. p. 1629.

14. *Experiments* on the Production and Propagation of *Light* from the *Phoſphorus* in *Vacuo*. n. 296. p. 1865.

15. *Experiments* concerning the Propagation of *Sounds* in *Condenſed* and *Rarefied* Air. n. 297. p. 1902.

16. *Experiments* concerning the *Refilition* or Rebounding of *Bodies* in *Various Mediums*. n. 298. p. 1946.

17. Some farther *Experiments* concerning the *Electricity* and *Light* produc'd from various *Bodies* by *Attrition* — of *Glaſs* — of *Sealing-Wax* — of *Sulphur* and *Roſin*. n. 315. p. 82.

18. An Account of the Succeſs of an *Attempt* to continue *ſeveral Atmoſpheres* of *Air* condens'd in the *Space* of *One*, for a conſiderable *Time*. n. 318. p. 217.

19. An *Experiment* concerning the Production of *Light* in an exhauſted Glaſs, *lin'd* on the *Inſide* with *Sealing-Wax*, upon an *Attrition* made on its *Outſide*. n. 318. p. 219.

20. *Experiments* concerning the *Aſcent* of *Liquids* between the *nearly contiguous Surfaces* of Bodies — between two *Glaſs Planes* in the *Open Air* — and in *Vacuo* — between *Marble* and *Braſs Planes* in the *Open Air*. n. 319. p. 258.

21. The *Aſcent* of *Liquors* between two *Round Glaſs Planes* in the *Open Air*. *Ibid.* p. 265.

22. The *Aſcent* of *Water* through a *Tube* fill'd with *Aſhes* in the *open Air* — and in *Vacuo*. *Ibid.* p. 262.

23. The *Aſcent* of *Liquors* in *Small Tubes* of *unequal Thickneſs*, but *equal Bores* or *Cavities*. *Ibid.* p. 260.

24. The *Aſcent* of various *Liquors* between two *Square Glaſs Planes*. *Ibid.* p. 266.

25. An Account of an *Experiment* concerning the *different Denſities* of the *Air*, from the greateſt Degree of *Heat* to that of *Cold* in our Climate. n. 315. p. 93.

26. An Account of an *Experiment* concerning the *different Weights* of the *ſame ſorts of Bodies*, but of very *unequal Surfaces* in *Water*, which were of *equal Weight* in *common Air*. n. 320. p. 306.

27. An *Experiment* concerning the *different Denſities* of *common Water* from the greateſt Degree of *Heat* in our Climate to the *Freezing* Point obſerv'd by a *Thermometer*. n. 319. p. 267.

28. *Experiments* in relation to the *Weight* of *common Water* under *different* Circumſtances. *Ibd.* p. 269.

n. 320.p.302. 29. An *Experiment* concerning the *Freezing* of *common Water*, and *Water purg'd of Air*.

Ibid. p. 304. 30. An *Experiment* concerning the *Freezing* of common *Water*, ting'd with a Liquid, ſaid to be extracted from *Shell-Lac*.

n. 321. p.367. 31. An *Experiment*, ſhewing that *actual Sound* is *not* to be *tranſmitted* through a *Vacuum*.

Ibid. p. 369. 32. An *Experiment* concerning the *Propagation of Sound* paſſing from the ſonorous Body *into the common Air*, in *one Direction* only.

Ibid. p 371. 33. An *Experiment* concerning the *Propagation of Sound* through *Water*.

n. 322.p.391. 34. An *Experiment*, ſhewing that an *Object* may become *Viſible* through ſuch an *Opake Body* as *Pitch* in the *Dark*, while it is under the Circumſtances of *Attrition* and a *Vacuum*.

n. 323.p.439. 35. An *Attempt* to produce *Light* on the Inſide of a *Globe Glaſs lin'd* with melted *Flowers* of *Sulphur*.

Ibid. p. 440. 36. A *Repetition* of the foregoing *Experiments*, &c.

n. 328.p.196. 37. *Experiments* concerning the *Time* requir'd in the *Deſcent of Bodies* of *different* Magnitudes and Weights, *&c.*

Ibid. p. 199. 38. *Experiments* concerning the *Effects* of *Air* paſs'd *through red hot Metals*, &c.

n. 328.p.204. 39. A *Deſcription* of the *Apparatus* for making *Experiments* on the *Refractions of Fluids*; With a Table of the *Specific Gravities*, *Angles* of *Obſervations*, and *Ratio* of *Refractions* of ſeveral Fluids.

n. 331.p.325. 40. A *Repetition* of an *Experiment* of Dr. *Hook*'s, concerning *two Liquors*, which when *mix'd together poſſeſs leſs Space*, than when *Separate*; with another *Experiment* confirming the ſame.

Ibid. p. 328. 41. An Account of an *Experiment*, concerning an Endeavour to produce *Light* through a *Metallic Body*, under the Circumſtances of *Attrition* and a *Vacuum*.

n. 332.p.395. 42. An Account of an *Experiment* concerning the *Direction* of a *Drop* of the *Oil* of *Oranges* between two *Glaſs Planes*, towards any ſide of them that is neareſt preſs'd together.

n. 333.p.431. 43. *Experiments* on keeping *Fiſhes* in *Water* under *different Circumſtances*.

n. 334 p.473. 44. Of the *Angle* requir'd to ſuſpend a *Drop* of the *Oil* of *Oranges*, at certain Stations, between two *Glaſs Planes*, plac'd in the Form of a *Wedge*.

n. 335.p 511. 45. The *Specific Gravities* of ſeveral *Metallic Cubes* in Compariſon with their *like Bulks* of *Water*.

n. 336.p.539. 46. An *Experiment* concerning the *Aſcent* of *Water* between two *Glaſs Planes* in an *Hyperbolic* Figure.

Ibid. p. 541. 47. A *Deſcription* of ſeveral *Strata* of *Earth*, *Stone*, *Coal*, &c. found in a *Coal-Pit* at the Weſt End of *Dudley* in *Staffordſhire*, by Mr. *Fettiplace Bellers*, F. R. S. To which is added a Table of the *Specific Gravity* of *each Stratum*, by Mr. *F. Hawkſbee*.

n. 335.p.505. 48. *Experiments* concerning the *Proportions* of the *Power* of the *Load-ſtone* at *different Diſtances*; with a Deſcription of the Load-ſtone made uſe of.

49. An *Experiment* concerning the *Proportions* of the *Aſcent* of *Spirit* of *Wine* between two *Glaſs Planes*, whoſe Surfaces were *plac'd* at *different Diſtances* from each other. n. 337. p. 151.

50. *Experiments* concerning the *Aſcent* of *Water* between two *Glaſs Planes* in an *Hyperbolic* Curve. *Ibid.* p. 153.

51. A farther Account of the *Aſcending* of *Drops* of *Spirit* of *Wine* between two *Glaſs Planes twenty Inches and a half long*; with a *Table* of the *Diſtances* from the *Touching Ends* and the *Angles* of *Elevation*. *Ibid.* p. 155.

CHAP. II.

Hydrology.

An Account of the Lake Vetter, *in* Sweden; *by Dr.* Urban Hearne. n. 298. p. 1938.

I. BOTH *Olaus Magnus* and other Writers having related ſome Things ſurpriſing and unuſual concerning the Lake *Vetter*, I thought it worth while to enquire more narrowly into the Nature of that *Lake*, and the Veracity of thoſe Authors; and where I had not an Opportunity of making Obſervations myſelf, to aſk the Teſtimonies of Perſons of a good Character living in the Neighbourhood of it, who could ſolve all my Queſtions with Matters of Fact.

The Lake *Vetter* running from North to South, from *Aſkerſund* in *Nericia* to *Jonekoping* in *Smoland*, meaſures fourteen *Swediſh* Miles in Length, one of which is equal to five or ſix Miles *Engliſh*, and ten of them make almoſt a Degree: But in Breadth it is only three Miles, and in ſome Places hardly more than two. This Lake upon Account of the high Mountains about it, which in ſome Places begin upon the Borders of it, and in other Places are at a little Diſtance from it, appear depreſſed towards the Shore to People ſtanding near it. It is remarkably deep, but its Depth is ſo unequal, that in ſome Places you find the Bottom at eighty Fathoms, but in ſeveral Parts on the Borders of *Oſtrogothland*, and in a few of *Weſtrogothland*, at three hundred Fathoms you find no Bottom. An Inhabitant of *Vadſten*, *Benedictus Amberni*, in order to ſound the Depth of the Lake upon the Borders of the State of *Grennen*, let down ſome Fathoms of Rope with a Hatchet at the End of it, but not finding any Bottom, when he gathered up the Rope, inſtead of the Hatchet he found a Horſe's Skull very neatly faſtened to it. An Abyſs like to this at the Precipices of the Mountain *Obmen*, which are called the *Weſtern Wall*, has always deceived thoſe who have attempted to ſound it; ſo that few dare venture upon it for fear of the Weſt Wind, which growing ſtormy of a ſudden eaſily loſes the Veſſels down the Sides of the Mountains in ſpite of all the Anchors they throw out on every Side. In the ſame manner formerly at a certain Province of *Weſtrogothland*, the Governor Count *Johannes Oxenſtiern* after throwing out three hundred Fathoms could find no Bottom, which is atteſted by ſome Fiſhermen ſtill alive, who were employed in that Affair. This Water is no leſs clear than it is deep, ſo that you can diſcern a very ſmall Piece of Money at a conſiderable Depth. *Ericus Simonius* Paſtor and Overſeer of *Vadſten* ſays, that in a clear Day he has been able to perceive a Silver Penny in the Water ſixty Fathoms deep. But at ſome Diſtance from the Surface it appears tinged ſomewhat green: And no wonder if the Filth coming from ſo many ſmaller Lakes, Mountains and Woods, ſhould taint this limpid Water conſiderably.

Although this *Lake of Vetter* is larger than moſt others, yet the moſt Part of it is free of Rocks, and there are very few Iſlands in it. The chief of theſe is called *Viſingſoe*, formerly the Seat of the Family of the *Brabde*, and lies in the Middle of the *Lake* between *Grenna* of *Smoland* and *Weſtrogothland*, and North from that is the Iſland of *Roknen* over againſt the Baths of *Medevien*. There are beſides theſe ſome ſmall Iſlands near the Shore, but they are very ſmall and few in Number. But being freely expoſed to Winds and ſurrounded with very high Mountains, no wonder if it is but ſeldom calm, and the Boats are toſſed upon it in frequent Storms; which come often ſo unexpected that there begins a Motion within it while the Waters are as ſmooth as a Mirror, before the leaſt Breath of Wind is felt. Which ſeems to be owing to the Tempeſt heaving up the Waters elſewhere, and gradually protruding them before the Winds have reached that Part. For it is no unfrequent Thing in the *Vetter* for the Veſſels to be toſſed by the Winds in one Part, while hard by it is ſo calm that others are obliged to make uſe of Oars. This ſeems to indicate that Commotions may be raiſed in the Waters by ſubterraneous Winds, and *Varenius* attempts to explain the like Effects in his *Univerſal Geography*. A great many Phænomena confirm this Conjecture. For when the Tempeſt and Clouds are threatening, you may perceive a kind of howling and thundering Noiſe in the Waters while the Air continues ſerene, which I had occaſion myſelf to hear ſeveral times while at the *Baths* of *Medevien* when the Air was quite calm, and was always followed with a violent Storm. But the Inhabitants of *Viſingſoe* are moſt ſenſible of this, having their Ears confounded with a Noiſe like that of Guns, from that Part of the Iſland whence they expect the Storm to come next Day. And when theſe Exploſions are heard towards the Eaſt, they have a Storm from that Quarter for the moſt part attended with Hail and Rain. The various puffing up of the Waters, the ſudden riſing of Vapours, and haſty flying out of Blaſts, which ſome People have obſerved in this Lake, are worthy to be taken Notice of. Something of this Kind was obſerved not without Surprize by *Abraham Winandz* the Architect, who happening once to paſs by thoſe Coaſts with ſome Friends, while the Waters were quite calm, ſaw little Clouds darting up from the Bottom here and there, and joining themſelves with the Air in Form of Smoak, fell down in gentle Showers upon them every now and then all that Day; all which argue ſtrongly that there are ſuch Things as ſubterraneous Winds.

Doubtleſs the ſame Wind, with the Storm coming from above, is the Cauſe why in the Spring, the Ice which juſt now is ſtrong and thick enough to bear Horſes and Carriages, is ſo broken and diſperſed, that you may preſently ſail very ſafely upon it. But before this dreadful breaking of the Ice, the horrible Noiſe of the Waters which precedes it, warns the frightened Travellers that are upon it to get off as quick as poſſible; but if they happen to be far from the Shore, they are either immediately drowned, or drove up and down for ſome Time upon Fragments of Ice, and ſometimes the Ice preſently ſinks when the Air is very little moved.

Whether or not there are metallic Vapours ſerving to produce theſe ſubterraneous Winds, I ſhall not pretend to determine. But that theſe are not wanting there is plain, from ſeveral Mountains of *Nericia* and *Weſtrogothland*, on the North Side of the *Vetter*, with Veins of Iron Ore, and perhaps more noble Metals more lately diſcovered, and other different Kinds of Minerals, *viz.* Antimony, Loadſtone, Chalk, Mica Sterilis, ſeveral Sorts of Silver and Lead Ores, and Marchaſite, whence Sulphur, Vitriol, Allum, and other foſſile Subſtances uſe to be extracted. And in the Waters themſelves there is found a great Quantity both of Marchaſite, and a ruſty Kind of Oker. The *Ignis fatuus* muſt likewiſe be referred to this Place, being not only obſerved frequently upon the Borders of the Lake, but in the Night Time it is ſeen flying in the Middle of the Waters, and confounds the Fiſhermen, and a great many are perſuaded that this is owing to metallic and ſulphureous Exhalations. Nor is the Granate, Porphyry, Jaſper, Chryſtal, and other precious Stones produced in this Lake, formerly collected by Count *Peter Brabens*, and ſo finely poliſhed, as to be uſed amongſt the bridal Ornaments of the Ladies of *Viſingſburg*, generated without the Aſſiſtance of mineral Vapours. All theſe acknowledge a mineral Origin, not to mention the Baths of *Medevien*, in the Borders of the *Vetter*.

Amongſt the other Properties of this Lake, we muſt not paſs over the remarkable Whirl-pools and violent Torrents here, which though they have only one Vent, yet being directly oppoſed to the Winds and Waves, are very troubleſome to the Fiſhermen. Hence it has been ſuſpected on Account of its vaſt Depth, and the private Channels, and ſubterraneous Winds, that there muſt be a Communication under Ground of the *Vetter* with another Lake, ten *Swediſh* Miles to the Weſt of it, called the *Venner*. And this is the more probable, from the different Quick-ſands that are betwixt theſe two Lakes, two of which, in the Pariſh of *Fegren*, called the black and white Quick-ſands, *Haddorphius* had meaſured. He found them to be of a prodigious Depth, and obſerved in them an inteſtine Motion, as if they were turgid with a Kind of Ferment. The ſame Opinion is likewiſe ſtrengthened from this, that ſome Years the *Vetter* is conſiderably ſwelled without any manifeſt Cauſe, and falls again afterwards the ſame Way. Mr. *Daniel Ridley* Miniſter at *Motala*, has obſerved concerning this *Lake* theſe ſeven Years by-paſt, that in ſome certain Places it gradually decreaſed, ſo as you could walk dry-footed ſome Fathoms, where Boats uſed formerly to go, the Seaſons in the mean Time, *viz.* in the Years 1680, 1682, 1684, and 1685, being every where ſufficiently rainy. But in the Year 1686, towards Autumn, the Waters began again gradually to increaſe till the preſent Year 1688. But whether the *Vetter* keeps its ſtated Times, the ſame as they ſay of the *Venner*, increaſing ſeven Years, and then diminiſhing other ſeven, I am not able to determine. It is likewiſe ſurpriſing, that in a ſerene Air they can hear the Cannon at *Stockholm* and other Places thirty Miles diſtant. So that in the Year 1685, when the Princes of *Stockholm* were buried, they heard the Report of the Cannon exactly at ſix o'Clock. And with the ſame Eaſe in the Year 1676 they heard the Exploſion of the Guns in a Sea-Fight diſtinctly at about thirty Miles Diſtance.

As to what *Olaus Magnus*, *Meſſenius*, and other Hiſtorians relate concerning *Gilbert*'s *Cave* in the Iſland of *Viſingſoe*, I leave to the Credit of theſe Authors. This however is certain, that there ſtill remains a Cavern full of a ſulphureous and very nauſeous Stench, which I imagine, according to the Opinion of the People in that Place, to be owing to the Naſtineſs gathered in Length of Time in the Cave ſituated near the Waters, exhaling ſulphureous and moiſt Vapours. And that there appear upon the Borders of it different Spectres and Phantoms, for the moſt part reſembling Women, ſometimes Horſes and other Animals, friſking about, no Body who is intent upon thoſe Curioſities will deny. There are ſeveral Stories both of former Ages and of the preſent, which I could bring in to confirm this, if I was not reſolved to paſs it over ſo ſlightly.

But I muſt not neglect to mention the famous River *Motala*, which, as I ſaid, is the only Mouth of the *Vetter*, and at certain Times uſes to lay aſide its Fluidity, and ſtop its Courſe in ſuch a Manner, as you could go freely into it, and ſometimes take up Fiſhes that were left in the Bottom of it without any Impediment, as it happened in the Years 1682 and 1685, about *Chriſtmas*. The common People in that Country are unanimouſly perſuaded, that the Courſe of the River is never ſtopt without ſomething bad following it, and that it always preſages either a great Dearth or a War, or ſome public Diſaſter, in the ſame manner as a Whale's coming into the *Thames* is ſaid by the *Engliſh* to portend ſomething fatal. But whatever Stories they have about, if they are not conformable to the Laws of Nature, give no Satisfaction to a phyſical Perſon, enquiring into the natural Cauſes of ſuch ſurpriſing Effects. I was therefore ſollicitous in enquiring into thoſe Things which ſeemed to give Light to this Phænomenon, although I never had the Opportunity of ſeeing the Courſe of the River ſtopt. But however variouſly the Inhabitants near this River attempt to explain this Affair, imagining that at that Time the Waters retiring from the Shores ſink into the Channel, yet I have always ſuſpected that this Part of the River above where the Current was ſtopt muſt be obſtructed with Ice or Snow, ſo as to dam it up, while the Waters below run on towards the Sea. And what gives a Foundation for this Opinion is, that this ſtopping of the River never happens in the Spring, Summer, or Autumn, but always about *Chriſtmas*, or the Beginning of the new Year; and that it is always near the Bridge, where the Water being at leaſt above three Yards deep, the Stone Pillars upon which the Bridge is built retard a good deal the Courſe of the River there. That this Conjecture is agreeable to Truth, the above-mentioned Miniſter of the Church at *Motala* aſſerts, both from his own Experience and that of other Perſons. His Houſe ſtands juſt upon the Borders of the Bridge, and ſays that there are long Herbs, ſuch as Water-Graſs, Knot-Graſs, *&c.* which ſhooting out from the Bridge into the neighbouring Current germinate in the Water, and the Ice faſtens to them like Knobs, and congealed Snow, which being puſhed away by the River, and ſtopt by the Pillars of the Bridge, at laſt may be heaped up ſo as to ſtop the Current. There are likewiſe a great many Builders there, who ſay, that before they expect the Current to be ſtopt, there are large Heaps of Snow ſent out from the Lake, which ſticking like Glue to whatever Body they meet with, ſink gradually to the Bottom. Nor is it an uncommon Thing for the Waters in the Lake one Day to be very quiet, and the next Day all in Commotion ſtopt near the Bridge. But whatever is the Cauſe of it, it is ſtill ſurpriſing, that this does not happen when the Cold is very intenſe, but when the Air is more mild, generally about *Chriſtmas*, or the Beginning of *January*. Perhaps the Cold continues ſtill violent under the Waters, though the Air is become milder, or the Ice become ſofter ſticks to the Herbs or other Obſtacles which it meets with in its Way, and produces theſe Obſtructions.

Some Particulars of a Fountain *near the Lake* Vetter.

But I muſt not paſs over in Silence ſome remarkable Particulars of a *Fountain* not far from the *Vetter* in the Pariſh of *Nyen* (where are the Baths of *Medevien* too) near the Church and the Miniſter's Houſe, which I had from the Miniſter there, whoſe Name is *Jonah Frodelius*, a very worthy Man, and alſo from others. They call it the hungry Fountain, or the Foreteller of the Crop, becauſe it is never quite filled with Water but there follows a Dearth next Year. It is ſurrounded on all Sides with ſoft ſandy Hills, in the Middle of which is a flat Valley, but not at all marſhy. Out of this riſes the Fountain by ſecret Veins, which has this Particular, that in a rainy Summer for the moſt Part it becomes dry, and on the contrary, in the drieſt Summers, immediately before a Dearth, and according to others (whom I am not at leiſure to meddle with) likewiſe before a War, it lays the high Road between *Motala* and *Vadſten* under Water, as is certified by a great many People who live there. In the Year 1685, which was very rainy, this Fountain was almoſt dry, and not above half a Foot deep; and in the Summer following, the Water began to increaſe. And the Truth of this is confirmed this preſent very dry Summer, this Spring having greatly abounded with Water, whilſt all the reſt in the Neighbourhood were quite dried up. But the chief Things to be obſerved about it are theſe.

1. That it preſages a bad Crop or Dearth to *Oſtrogothland* only of all the Places that are nigh it.
2. This whole Country, eſpecially in the Neighbourhood of the Fountain, is of a very ſandy Soil, in ſome Parts mixed with a very hard Clay, and therefore requires a great deal of Water to make it fertile. Beſides too,
3. The Crops are only bad there in dry Seaſons, whilſt the contrary happens in *Iemptia*, and other more Northern Provinces.
4. That the Plenty of Meteors, and of the Seaſon, ſometimes depends upon the Diſpoſition of the Earth, and what lies hid under its Surface.
5. That the Waters of this Fountain, ſtrained as it were through the Sand near the Sand Hills, are collected together by inſenſible Veins.
6. That the Waters may be increaſed or ſwelled up before a dry Seaſon, and fall away in a rainy one, for phyſical Cauſes, to treat of which more largely I ſhall take another Opportunity.

A New Contrivance *for* Diving, *&c.* *by Dr.* E. Halley. 349. p. 492.

II. Many Methods have been propoſed, and many Engines contriv'd, for enabling *Men* to abide a competent while under *Water*: And the reſpiring freſh *Air* being abſolutely neceſſary to maintain Life in all that breathe, ſeveral Ways have been thought of for carrying this down to the *Diver*, who muſt, without being ſupply'd therewith, return very ſoon, or periſh.

We have heard of *Divers* for Spunges in the *Archipelago*, helping themſelves by carrying down *Spunges* dipp'd in Oil in their Mouths; but conſidering how ſmall a Quantity of *Air* can be ſuppos'd to be contain'd in the Interſtices of a *Spunge*, and how much that little will be contracted by the Preſſure of the *incumbent Water*, it cannot be believ'd that a Supply, by this Means obtain'd, can long ſubſiſt a Diver. Since by Experiment it is found that a Gallon of Air included in a Bladder, and by a Pipe reciprocally inſpir'd and expir'd by the Lungs of a Man, will become unfit for any further Reſpiration, in little more than one Minute of Time; and though its Elaſticity be not much alter'd, yet in paſſing the Lungs, it loſes its vivifying Spirit, and is render'd effete, not unlike the Medium found in Damps, which is preſent Death to thoſe that breathe it; and which, in an Inſtant, extinguiſhes the brighteſt Flame, or the ſhining of glowing Coals, or red hot Iron, if put into it. I ſhall not go about to ſhew what it is the Air loſes by being taken into the Lungs, or what it communicates to the Blood by the extreme Ramifications of the *Aſpera Arteria*, ſo intimately interwoven with the Capillary Blood-Veſſels; much leſs to explain how it is perform'd, ſince no Diſcovery has been made to prove that the ultimate Branches of the Veins and Arteries there, have any *Anaſtomoſes* with thoſe of the *Trachæa*; as by the Microſcope they are found to have with one another. But I leave this to the Anatomiſts; and only conclude from the aforeſaid Experiment, that a naked Diver, without a Spunge, cannot be above a Couple of Minutes incloſ'd in Water, (as I once ſaw a *Florida-Indian* at *Bermudas*) nor much longer with a Spunge, without ſuffocating; and not near ſo long without great Uſe and Practice: Ordinary Perſons generally beginning to ſtifle in about half a Minute of Time. Beſides, if the Depth be conſiderable, the Preſſure of the Water on the Veſſels is found by Experience to make the Eyes Blood-ſhot, and frequently to occaſion ſpitting of Blood.

When therefore there has been Occaſion to continue long under Water, ſome have contriv'd double flexible Pipes to circulate Air down into a Cavity encloſing the Diver, as with Armour, to bear off this Preſſure of the Water, and to give leave to his Breaſt to dilate upon Inſpiration: The freſh Air being forc'd down by one of the Pipes with Bellows, or otherwiſe, and returning by the other of them, not unlike to an Artery and Vein. This has indeed been found ſufficient for ſmall Depths, not exceeding twelve or fifteen Foot: But when the Depth ſurpaſſes three Fathoms, Experience teaches us, that this Method becomes impracticable: For though the Pipes and the reſt of the *Apparatus* may be contriv'd to perform their Office duly, yet the Water (its Weight being now become conſiderable) does ſo cloſely embrace the Limbs that are bare, or cover'd with a flexible Covering, that it obſtructs the Circulation of the Blood in them; and preſſes with ſo much Force on all the Junctures, where the Armour is made tight with Leather, Skins, or ſuch like, that if there be the leaſt Defect in any of them, the whole Engine will inſtantly fill with Water, which will ruſh in with ſo much Violence, as to endanger the Life of the Man below, who may be drown'd before he can be drawn up. Upon both theſe Accounts, the Danger encreaſes with the Depth. Beſides, a Man thus ſhut up in a weighty Caſe, as this muſt needs be, cannot but be very unwieldy and unactive, and therefore unfit to execute what he is deſign'd to do at the Bottom.

To remedy theſe Inconveniences, the *Diving-Bell* was next thought of; wherein the *Diver* is ſafely convey'd into any reaſonable Depth, and may ſtay more or leſs Time under Water, according as the *Bell* is of greater or leſſer Capacity. This is moſt conveniently made in the Form of a Truncate Cone, the ſmaller Baſis being cloſed, and the larger open; and ought to be ſo poiz'd with Lead, and ſo ſuſpended, that the Veſſel may ſink full of Air, with its greater or open Baſis downwards, and as near as may be in a Situation parallel to the Horizon, ſo as to cloſe with the Surface of the Water all at once. Under this Couvercle the Diver ſetting, ſinks down together with the included Air; and if the Cavity of the Veſſel may contain a Tun of Water, a ſingle Man may remain therein at leaſt an Hour, without much Inconvenience, at five or ſix Fathoms deep. But this included Air, as it deſcends lower, does contract itſelf according to the Weight of the Water that compreſſes it; ſo that at thirty three Feet deep or thereabouts, the Bell will be half full of Water, the Preſſure of it being then equal to that of the whole Atmoſphere. And at all other Depths, the Space occupied by the compreſs'd Air in the upper Part of the Bell, will be to the under Part of its Capacity fill'd with Water, as thirty three Feet to the Depth of the Surface of the Water in the Bell below the common Surface thereof. And this condens'd Air, being taken in with the Breath, ſoon inſinuates itſelf into all the Cavities of the Body, and has no ſenſible Effect, if the Bell be permitted to deſcend ſo ſlow as to allow Time for that Purpoſe. The only Inconvenience is found in the Ears, within which there are Cavities opening only outwards, and that by Pores ſo ſmall as not to give Admiſſion even to the Air itſelf, unleſs they be dilated and diſtended by a conſiderable Force. Hence on the firſt Deſcent of the Bell, a Preſſure begins to be felt on each Ear, which by Degrees grows painful, like as if a Quill were forcibly thruſt into the Hole of the Ear; till at length the Force overcoming the Obſtacle, that which conſtringes theſe Pores yields to the Preſſure, and letting ſome condens'd Air ſlip in, preſent Eaſe enſues. But the Bell deſcending ſtill lower, the Pain is renew'd, and again eas'd after the ſame Manner. But when the Engine is drawn up again, the condens'd Air finds a much eaſier Paſſage out of thoſe Cavities, and even without Pain. This Force on the auditory Paſſages might be ſuſpected to be prejudicial to the Organs of Hearing, but that Experience teaches otherwiſe. But what is more inconvenient in this Engine, is, the Water entering into it, ſo as to contract the Bulk of Air (according to the aforeſaid Rule) into ſo ſmall a Space, as that it ſoon heats and becomes unfit for Reſpiration, for which Reaſon it muſt be often drawn up to recruit it: And beſides the Diver being almoſt cover'd with the Water thus entering into his Receptacle, will not be long able to endure the Cold thereof.

To obviate theſe Difficulties which attend the Uſe of the common Diving-Bell, I have thought of Means to convey Air down to it, whilſt below; whereby not only the Air included therein, would be refreſh'd and recruited, but alſo the Water wholly driven out, in whatever Depth it is; and will furniſh Air at the Bottom of the Sea in any Quantity deſir'd. The Deſcription of my *Apparatus* take as follows:

The Bell I made uſe of was of Wood, containing about ſixty Cubick Feet in its Concavity, and was of the Form of a Truncate Cone, whoſe Diameter at Top was three Feet, and at Bottom five. This I coated with Lead ſo heavy, that it would ſink empty, and

I diſtributed the Weight ſo about its Bottom, that it would go down in a perpendicular Situation, and no other. In the Top, I fix'd a ſtrong, but clear Glaſs, to let in the Light from above; and likewiſe a Cock to let out the hot Air that had been breath'd; and below, about a Yard under the Bell, I plac'd a *Stage* which hung by three Ropes, each of which was charg'd with about one hundred Weight, to keep it ſteady. This Machine, I ſuſpended from the Maſt of a Ship, by a *Spritt*, which was ſufficiently ſecur'd by *Stays* to the Maſt-head, and was directed by *Braces* to carry it over board clear of the Ship-ſide, and to bring it again within board.

To ſupply Air to this Bell when under Water, I cauſed a couple of Barrels, of about 36 Gallons each, to be cas'd with Lead, ſo as to ſink empty, each having a Bung-hole in its loweſt Part, to let in the Water, as the Air in them condens'd on their Deſcent; and to let it out again, when they were drawn up full from below. And to a Hole in the uppermoſt Part of theſe Barrels, I fix'd a Leathern Trunk or Hoſe, well liquor'd with Bees-Wax and Oil, and long enough to fall below the Bung-hole, being kept down by a Weight appended; ſo that the Air in the upper Part of the Barrels could not eſcape, unleſs the lower Ends of theſe Hoſe were firſt lifted up.

I fitted theſe Air-Barrels with Tackle proper to make them riſe and fall alternately, after the Manner of two Buckets in a Well; which was done with ſo much Eaſe, that two Men, with leſs than half their Strength, could perform all the Labour; and in their Deſcent they were directed by Lines faſten'd to the under Edge of the Bell, which paſs'd through Rings plac'd on both Sides the Leathern Hoſe in each Barrel; ſo that ſliding down by thoſe Lines, they came readily to the Hand of a Man, who ſtood on the Stage on purpoſe to receive them, and to take up the Ends of the Hoſe into the Bell. Through theſe Hoſe, as ſoon as theſe Ends came above the Surface of the Water in the Barrels, all the Air that was included in the upper Parts of them, was blown with great Force into the Bell, whilſt the Water enter'd at the Bung-holes below, and fill'd them: And as ſoon as the Air of one Barrel had been thus receiv'd, upon a Signal given, that was drawn up, and at the ſame Time the other deſcended; and by an alternate Succeſſion furniſh'd Air ſo quick, and in ſuch Plenty, that I my ſelf have been one of five, who have been together at the Bottom, in nine or ten Fathoms Water, for about an Hour and half at a Time, without any Sort of ill Conſequence: And I might have continu'd there as long as I pleas'd, for any Thing that appear'd to the contrary. Beſides the whole Cavity of the Bell was kept entirely free from Water, ſo that I ſat on a Bench, which was diametrically plac'd near the Bottom, with all my Cloaths on. I only obſerv'd, that it was neceſſary

ceſſary to be let down gradually at firſt, as about 12 Feet at a Time; and then to ſtop and drive out the Water that enter'd, by receiving three or four Barrels of freſh Air, before I deſcended farther. But being arriv'd at the Depth deſign'd, I then let out as much of the hot Air that had been breath'd, as each Barrel would repleniſh with cool, by means of the Cock at the Top of the Bell; through whoſe Aperture, though very ſmall, the Air would ruſh with ſo great Violence, as to make the Surface of the Sea boil, and to cover it with a white Foam, notwithſtanding the great Weight of Water over us.

Thus I found I could do any Thing that was requir'd to be done juſt under us; and that, by taking off the Stage, I could, for a Space as wide as the Circuit of the Bell, lay the Bottom of the Sea ſo far dry, as not to be over Shoes thereon. And by the Glaſs Window ſo much Light was tranſmitted, that, when the Sea was clear, and eſpecially when the Sun ſhone, I could ſee perfectly well to write or read, much more to take up any Thing that was under us: And by the Return of the Air-Barrels, I often ſent up Orders, written with an Iron Pen on ſmall Plates of Lead, directing how to move us from Place to Place. At other Times, when the Water was troubled and thick, it would be as dark as Night below; but in ſuch a Caſe, I have been able to keep a Candle burning in the Bell as long as I pleas'd, notwithſtanding the great Expence of Air requiſite to maintain Flame.

I take this Invention to be applicable to various Uſes; ſuch as *Fiſhing* for *Pearl*, *Diving* for *Coral*, *Spunges*, and the like, in far greater Depths than has hitherto been thought poſſible: Alſo for the fitting and plaining of the Foundations of Moles, Bridges, *&c.* upon rocky Bottoms; and for the cleaning and ſcrubbing of Ships Bottoms when foul, in calm Weather at Sea.

By an additional Contrivance, I have found it not impracticable for a Diver to go out of this Engine to a good Diſtance from it, the Air being convey'd to him with a continu'd Stream, by ſmall flexible Pipes; which Pipes may ſerve as a Clue to direct him back again, when he would return to the Bell.

Of an Eruption *of* Waters *in* Yorkſhire, *by Mr.* R. Thoreſby. n. 306. p. 2236.

III. I have lately enquir'd of a Neighbour concerning the extraordinary Eruption of Waters at *Craven*, which the Vicar of *Kildwick* ſent (†) an Account of to the *Royal Society*: I am not only fully ſatisfied of the Truth of what Mr. *Pollard* ſays, but alſo, that, as he conjectures, a great Part of the Land is not to this Day recover'd from the Sand and Stones, though a great Number of People were employ'd about it. Upon the *opening of the Rock*, at the Foot of which the Town of *Starbotham* ſtands, the Water guſh'd out in ſo vaſt a Quantity, as if it would have ſwept away the whole Town. The Waters

(†) *Vid.* Supra V. II. C. II. S. XXXIV.

Waters came rolling impetuouſly down, almoſt at once; ſeveral Houſes were utterly ruin'd, and others wreck'd up to the Chamber Windows; one, particularly, was ſo cover'd, that a great Piece of the Rock was left upon the Top of the Chimney. My Neighbour was an Eye-witneſs of this ſad Accident, and has ſpent much Time in clearing ſome Part of his Land.

Of Inundations *in* Ireland, *by Mr.* Neve. n. 320. p. 309.

IV. On *October* the *7th*, 1706, after a very rainy Day, and ſoutherly Wind, there happen'd a prodigious Flood in the North of *Ireland* (the like not in the Memory of Man) which broke down ſeveral Bridges, and the Sides of ſome of the Mountains. It came running down in vaſt Torrents from the Mountains, and drown'd abundance of black Cattle and Sheep, ſpoil'd a great deal of Corn and Hay in the Stacks; it laid abundance of Houſes two or three Feet deep in Water, and broke down ſeveral of the Forges and Mill-Dams.

On *July 3d*, 1707, there happen'd another *Flood*, which came ſo ſuddenly from the Mountains, as if there had been ſome ſudden Eruption of the Waters. And on the *26th* of the ſame Month, in the County of *Antrim*, there happen'd a very ſudden and ſurprizing *Flood*, which rais'd the *Six-Mile-River* at that Rate, that it broke down two ſtrong Stone Bridges, and three Houſes, and carried away 600 Pieces of Linnen Cloath that lay bleaching, fill'd ſeveral Houſes ſeveral Feet deep with Water, tore down ſome large Rocks in its Paſſage, and left ſeveral Meadows cover'd a Foot or two deep with Sand. In the South-Eaſt Part of the County of *Derry*, they had that Day but little Rain, with ſome Thunder; but beyond the Mountains, in the North-Weſt Part of the County, the River *Roe* had a great Flood.

Obſervations *on the Lake* Lough-Neagh *in* Ireland, *by Mr.* F. Neville. n. 337. p. 260.

V. There is no petrifying Quality in the Water of the Lake *Lough-Neath*, as ſome believe; I have liv'd 14 Years at *Dungannon*, within five Miles of it, and have been often there about the Skirts for many Miles, and in a Boat upon it ſeveral Times; I have view'd it often when the Waters have been very low, and a large Strand left in ſeveral Places: And many Trees lay in the Verge of the *Lough* (of which, I believe, ſome might have lain there ſome hundreds of Years) which had been over-turn'd by the *Lough*'s encroaching on the Land, where great Woods had grown; and many Roots of great Trees were ſtanding in their proper Places, where the Water had prevail'd on the Land; and I perceiv'd no Alteration in the Wood at all, but it was firm, ſound Wood, without any Petrifaction.

Mr. *Brownlow* told me, that he had drove ſeveral Holly Stakes into the Ground within the Verge of the *Lough*, and that ſome of them continu'd there many Years, but that he found no Alteration.

There has indeed been great Quantities of ſuch ſort of Stone, like to Wood, found upon the Strand after great Floods and Storms of Wind, which have put the *Lough* into a Ferment; the Waves breaking down the Banks, encroaching on the Land, and tumbling over Trees, by which Encroachment this Sort of Stones are diſcover'd: And if ever they were Wood, they were petrify'd by the Earth, and not by the Water; of which kind I have ſeen ſeveral Pieces big and little, ſome like Oak, ſome Aſh, and ſome like Holly, with Bark, Grain, and Knots, like Wood; ſo that any by the Eye would judge it Wood, till they come to try it. I had a Piece about ſixteen Inches long, that look'd as if it had been a great Chip cut out of the Side of an Oak Block, with the Bark on it; and in cutting ſuch large Chips, there happens generally ſuch Shakes and Flaws, ſo that there will be a Separation of Parts at one End, and they remain firm at the other, as it was in this. I could have rais'd ſeveral of ſuch Splinters, of this large Chip, ſome bigger, and ſome leſs; and when ſo rais'd, they would have ſlapp'd down as though they were a Spring. Some of thoſe Stones would appear at one End as if rotten, and decay'd Wood; but trying it, it was as much Stone, as any other Part.

The Lake is reputed to be twenty four Miles long, and twelve Miles broad, and Navigable from *Charlemount* to *Portlenone*, which is about thirty five Miles. It does not abound with many Sorts of Fiſh; but, thoſe that are, are very good; ſuch as Salmon, Trout, Pike, Breame, Roach, Eels, and *Pollans*, with which laſt, it does abound. The *Engliſh* call them *Freſh-water Herrings*. They catch them in the Summer with Sieves, as they do Herrings. They are much in Shape and Bigneſs like to the largeſt Smelts, full of very large bright Scales, and pleaſant Meat, being eat freſh. Theſe were ſuppos'd to be a Fiſh peculiar to that Lake; but ſince I came here, I find *Lough Earne* has the ſame Sort, but not in ſo great a Plenty. They are generally caught here in their Eel-Nets, running to the Sea; ſo that I am of Opinion, that they are that Sort of Fiſh that is caught in the Sea, or between the freſh and ſalt Water, call'd *Shads*; and that the large ones come from the Sea, as the Salmon doth, and leave their Spawn in the *Lough*; which, when they grow to be big, go to the Sea, and there come to their full Growth: And that which confirms me in my Opinion, is, that at the Salmon Fiſhing at *Coleraine*, they catch many of the large ones going up to the *Lough*. There is one ſort of Trout in *Lough-Neagh* very large: I have ſeen one weigh 30 Pound weight; and the largeſt Salmon that I ever ſaw, weigh'd not more than 35. This ſort of Trout the *Iriſh* call a *Budagh*.

Fiſh Pollans.

That there is ſome healing Quality in the Water of this *Lough* is certain; but whether diffuſ'd through all Parts thereof is not known, nor pretended. The *Fiſhing Bay*, which is about half a Mile broad, hath a fine ſandy Bottom, where any one may walk with Safety and Eaſe from the Depth of his Ankle to his Chin, upon an eaſy Declivity, at leaſt three hundred Yards before a Man ſhall come to that Depth. Others, as well as myſelf, have obſerv'd that the Bottom has chang'd from Cold to Warm, and from Warm to Cold, and this in different Spots through the Bay.

The firſt Occaſion of taking Notice of this Bay for Cure, was in the Reign of King *Charles* the Second: There was one Mr. *Cunningham*, who had an only Son grown to Man's Eſtate. This young Man had the Evil to that Degree, that it run upon him in eight or ten Places: He had been touch'd by the King, and all Means imaginable had been us'd for his Recovery; but all did no good, and his Body was ſo waſted, that he could not walk. When all Hopes of his Recovery were paſs'd, he was carried to the *Lough*, where he was waſh'd and bath'd; and in eight Days Time, bathing each Day, all the Sores were dry'd up, and he was cur'd, and grew very healthy, married, begot Children, and liv'd nine or ten Years after. This Account I had from Capt. *Marris*, and his Brother, who were Eye-Witneſſes. After ſo remarkable a Cure, many came there, who had running Sores upon them, and were cur'd after a little Time. The Natives thought it could not do well, but upon ſome particular Time appropriated for that Service; and now great Crowds come there on *Midſummer-Eve*, of all ſorts of Sick; and ſick Cattle are brought there likewiſe, and driven into the Water for their Cure; and People do believe they receive Benefit. I know it dries up running Sores, and cures the Rheumatiſm, but not with once bathing, as People now uſe it; and the drinking the Water, I am told, will ſtop the Flux. I look upon it to be one of the pleaſanteſt Bathing Places I ever ſaw.

Of the Eruption *of a* Burning Spring *in* Shropſhire, *by Mr.* R. Hopton. n. 334. p. 475.

VI. About *June* 1711, at *Broſely* near *Wenlock* in *Shropſhire* (about two Nights after a remarkable Day of Thunder) there was heard a terrible Noiſe in the Night, which awaken'd ſeveral People; who riſing to ſee what it was, came at laſt to a Boggy Place under a little Hill, about 200 Yards off the River *Severn*; where they perceiv'd a mighty Rumbling and Shaking in the Earth, and a little boiling up of Water through the Graſs: They took a Spade, and digging up ſome Part of the Earth, immediately the Water flew up to a great Height, and a Candle, that they had, ſet it on Fire.

To prevent the Spring being deſtroy'd, there is an Iron Ciſtern plac'd about it, with a Cover upon it to be lock'd, and a Hole in the Middle thereof; that any who come may ſee the Water thro'.

If you put a lighted Candle, or any Thing of Fire to this Hole, the Water immediately takes Fire, and burns like Spirit of Wine, and continues to do ſo as long as you can keep the Air from it; but by taking up the Cover of the Ciſtern it quickly goes out: The Heat of this Fire much exceeds the Heat of any Fire I ever ſaw, and ſeems to have more than ordinary Fierceneſs with it.

Some People out of Curioſity, after they have ſet the Water on Fire, have put a Kettle of Water over the Ciſtern, and in it Green Peaſe, or a Joint of Meat, and boil'd it much ſooner than over any Artificial Fire that can be made. If any green Boughs, or any Thing elſe that will burn, is put upon it, it preſently conſumes them to Aſhes.

The Water of itſelf is as cold as any Water I ever felt; and what is remarkable, as ſoon as ever the Fire is out, if you put your Hands into it, it feels as cold as if there had been no ſuch Thing as Fire near it. It ſtill [in *September*] continues boiling up with a conſiderable Noiſe.

Of a Mineral Water *at* Canterbury, *by Dr.* Mouſins. n. 312. p. 2462.

VII. About twelve Years ago a *Mineral Water* was accidentally diſcovered in *Canterbury*. In digging the Ground, they firſt met with a black fat Mold, extending itſelf three Feet deep, and gradually changing into another Sort of Earth, very fat, and like Butter. This ſecond Lay was two Feet thick; the Colour of it Yellow, ſomething mix'd; its Odour ſtrong and Mineral; and a Piece of it being for ſome Time expos'd to the Sun, ſmell'd much like burning Sulphur. After this they found a Quickſand of a darker Colour than the firſt Earth, mix'd with ſeveral little Stones, and the Smell ſtronger than before. Two Feet further, under the Quickſand, a hard Rock appear'd, out of which Water guſh'd with ſome Violence. They dug two Wells at about ſeven Feet diſtance from each other; one about eight or nine Feet from its Surface, and twelve from the Surface of the Ground about it, and reacheth the Rock: The other is not ſo deep by two Feet, and only toucheth the Sand. This laſt is ſomething ſtronger of the Sulphur, but the other is ſtronger of the Mineral Spirit and ferruginous Parts.

Two Drams of the ſecond Lay of Earth, found in digging, being put into four Ounces of Spirit of Vinegar, there preſently aroſe a conſiderable Ebullition; and ſoon after the Spirit was ting'd with a yellow browniſh Colour, which ſuffer'd no Alteration with the Infuſion of Logwood, nor with Galls, but with Oil of *Tart. p. deliq.* turn'd greeniſh, and with the Infuſion of *Lig. neph.* of a pale Red.

The Water taken up at the Spring is extraordinary limpid, but grows ſomething whitiſh in a quarter of an Hour, and in half an Hour the Spirit is loſt, and the Mineral hangs firſt on the Sides of the Glaſs, and then falls gradually to the Bottom. It won't keep quite ſo well as the *Spaw* or *Tunbridge* Water. Its Taſte is maſculine and auſtere; the Smell ferruginous and ſtrong, ſomething upon the Sulphur: People ſay it ſmells like Gun-powder. It will make the Root of the Tongue of the Drinkers look blackiſh. Linnen waſh'd in it turns yellow. It will not lather with Soap. The Glaſſes the Water is dipp'd with grow yellow, which no Scowering can take off, and are apt to fly. In froſty and cold Weather it is ſo warm as to melt Ice and Snow; in other Seaſons 'tis cold; tho' not ſo cold as ſome Spring Waters are.

The Weight of this Water varies much according to the Seaſons of the Weather. In *May* 1704, it weigh'd three Grains lighter than common Water in the Quantity of a Pound. In the Spring of 1705, it was equal in Weight to common Water; and is now ſtill heavier in *Auguſt* following, becauſe of the exceeding dry Weather of that Summer. But in general about *Midſummer*, if the Weather is no ways extraordinary, 'tis pretty equal to common Water in Weight.

A ſingle Grain Weight of good Gall will turn a Pint and a half of this Water of a very noble deep Red, and in an Inſtant. Syrup of Violets turns it of a Graſs green. With the Infuſion of *Braſile*, it giveth a deep lively Blue: With that of *Lign. neph.* firſt a light Green, then a light Yellow, with a blue Crown: With the Infuſion of Logwood, a blue Black: With that of Fuſtick Wood, a duſky Yellow: With the Flowers of Pomgranates, a fair Violet: With the Leaves of Tea, a fine purpliſh Blue: With good *Nantz* Brandy, an elegant Sky-colour. It turns a Solution of the *Sacch. Saturni* milky in an Inſtant; and the Solution of *Sublimate* in ſome Time longer. *Ol. Tart. per deliq. Sp. Sal. Armon. Sp. Vitr. &c.* make no ſenſible Alteration.

In calm Weather, in Winter eſpecially, a thick oily Film covers the Surface of theſe Waters, of as great a Variety of Colours as a Rain-bow; a Spoonful of it drunk, hath the Effect of, and compoſes as much to Sleep as, a moderate Doſe of Opium. Some of this Scum, being dry'd by Evaporation, taſted very fat, and felt ſo between the Fingers. Some of this Powder being caſt upon a red hot Iron, moſt of it immediately burn'd away with ſparkling; and what remain'd was of the Colour of Ruſt of Iron, and taſted partly Stiptic and Earthy, and partly Saltiſh.

The Water itſelf, being gently evaporated, yields a yellowiſh Sediment, more or leſs, according to the Seaſons. Laſt Spring a Quart yielded ſix Grains of it; but in *September* following, the ſame Quantity afforded me nine Grains; whereas a Pound of *Tunbridge* Water gave but one ſingle Grain of Sediment to Mr. *Boyle*, as appears by his *Memoirs of Mineral Waters*. This Sediment, being boil'd in common Water, made a ſtrong *Lixivium*, with which Acids caus'd no ſenſible Fermentation; but Syrup of Violets turn'd it Green. This *Lixivium* being evaporated, yielded a fat Sulphurous Salt, that would not coagulate into Cryſtals. I can get but three or four Grains of it out of ten Grains of Sediment; but from the Colour and Taſte of the *Lixivium*, I have Reaſon to ſuſpect, that there is a larger Proportion of Saline Particles, which, as I conceive, being Volatile, evaporate away with the Water.

As for its Medicinal Virtues, from the many and truly wonderful Cures, I believe it to be one of the moſt excellent Waters of this Kind, as yet found out in *England*. The little Well is very uſeful in Diſeaſes of the Breaſt, as in Aſthmas, Coughs, Rheums and Catarrhs. It hath cur'd ſeveral given over of Conſumptions of the Lungs. Moſt Diſorders of the Stomach are cur'd by this Water. It ſeldom fails in the Cure of Rheumatick Gouty Pains of the Limbs, or other Parts of the Body, in the Scurvy and Melancholy Diſtempers, Jaundice, Vapours, all ſorts of Stoppages, Scabs, Itch, *&c.* But in Gravel, Cholick, and Green-ſickneſs, 'tis a true Specifick; as alſo in inward Ulcers, if not too far gone. A Porter of *Bolton*, who had been with many Doctors, and was laſt Spring diſcharg'd out of St. *Thomas*'s Hoſpital, as an incurable Perſon, hath been cur'd of his Ulcer in the Bladder this Summer, with drinking of this Water for three Months together.

In Agues it is beyond the Bark: I have ſeen ſome Rebellious ones, that could not be remov'd by the Bark, perfectly cur'd by this Water, and ſome Conſtitutions quite worn out by the frequent Relapſes of this Diſtemper, reſtor'd again. This is alſo remarkable, that it agrees beſt with old, decay'd, and weak Conſtitutions. The Water ſits pleaſantly upon the Stomach, works off by Urine very briſkly, cauſeth a good Appetite, clears the Spirits, and procures Sleep. It is not binding, as ſome other Chalybeats are, but keeps the Body open to moſt People, and upon ſome it brings now and then a gentle Looſeneſs, which carries off the Diſtemper. For theſe four Years I have preſcrib'd them to many Scores of People every Seaſon, and I could never obſerve any Inconveniency, or ill Symptom ariſe from the Drinking of them.

An Examen *of the* Spaw Waters, *proving them to be* Alcalies, *by Dr.* F. Slare. n. 337. p. 247.

VIII. I have long ſince been of Opinion, that People have been miſtaken in their Notions about the Nature and Properties of thoſe Mineral Waters, which are of the *Chalybeat* or Iron Species. *Germany* abounds much with theſe Waters, and they beſtow one general Name upon them, and call them *Sour Brunns*, that is, *Sour* Wells, or Springs of Water. *Henricus ab Heers* agrees with *Vitruvius*, *Fallopius* and *Helmont*, in juſtifying the Acidity of ſeveral ſorts of *Spaw* and *Chalybeat* Waters; but, not being ſatisfied with their Reaſons, aſſigns others; and after a tedious Harangue, concludes, that they owe their Birth and great Virtues to Vitriol and Sulphur. He obſerves, that Vitriol and Sulphur are found in the Glebe or Earth from whence theſe Waters ſpring; but yet does not give us one Proof or Experiment of his having found any real Vitriol, or true Sulphur, or any Acidity in theſe Waters.

Dr. *Jordis*, who practiſed Phyſick at *Francford*, and often at *Swalbac* in Summer Time, at my Deſire, examin'd thoſe Waters. He gave me an Account of ſome *Ocres*, or Ferruginous Parts, which he calcin'd and tortur'd in the Fire, to make them confeſs their Sulphur Original; but in all his Experiments did not ſatisfy me, that the Water held one Drop of an Acid by Diſtillation, *&c.*

That which gave me the firſt Suſpicion, that the *Chalybeat* Waters did not contain any rough, or vitriolic, or acid Salts in them, proceeded from an accidental Uſe of a ſtrong Iron Water, in which I diſſolv'd Soap, and found it lather and waſh my Hands well, and then I us'd a Waſhball and ſhav'd with it, and try'd ſeveral other Waters of this ſort, which did the ſame, and much better than ſome Pump-Waters.

I conſulted my Palate, and try'd whether I could diſcover any Sharpneſs or Acidity in our *Engliſh* Steel-Waters at *Tunbridge*, at *Black-Boy* in the Pariſh of *Franſield* in *Suſſex*, *Hampſted*, *Sunning-Hill* in *Berkſhire*, &c. but I was ſo far from diſcovering any ſuch Thing, that theſe Waters ſeem'd rather to leave a ſweetiſh Flavour behind: Thus many Alkali Salts, if nicely examin'd (of the fix'd kind) have affected my Taſte.

I made Experiments with ſeveral Sorts of ſuch Spirits as are apt to ferment with Acids; ſuch as Spirit of *Hartſhorn*, of *Sal Armoniac*, &c. but theſe made no Ferment, nor any Motion or Change in theſe Waters.

I conſider'd the Diſeaſes in Human Bodies, which theſe Waters were preſcrib'd, by Phyſicians, to cure; that they were often ſuch as proceeded from ſharp, acid, or acrimonious Cauſes, as *Cardilage*, or Heart-burnings, ſour Vomitings, corroſive *Diarrhæas*, Cholicks, from Scurvies and Stranguries; and that for theſe Diſtempers ſweetning and alkaliſate Remedies are made uſe of.

I conſider theſe Waters as containing in them the Properties of Iron; and I find by Experience, that it is moſt oppoſite to Acids, being one of their great Correctors, and therefore rather to be eſteem'd an Alkali.

Take ſome Filings of Iron, perhaps a Dram, and pour on them about an Ounce of the milder Acids, ſuch as Vinegar, Verjuice, or the Juice of Lemons, and it will deſtroy the Sharpneſs of theſe Juices: Or if you pour on theſe Filings Mineral Acids, as the very corroſive Spirit of Nitre, or of Salt, or what is call'd Oil of Vitriol, they will immediately loſe their Acidity, be diſarm'd of their ſharp Points, and by Evaporation give a Salt that will taſte ſweetiſh, and is by Chymiſts call'd *Saccharum Martis*, if duly prepar'd; which is ſafely given inwardly, and is eſteem'd a good altering Medicine.

Steel beaten to a fine Powder, is, without any farther Preparation, given inwardly with great Succeſs for Stomachic Diſeaſes, as in the Green-Sickneſs, Hypochondriac, and various other Acid and Acrimonious Diſaffections.

I conſider'd Milk to be a very proper and obvious Subject to bring this Controverſy to a plain and unqueſtionable Deciſion. I made this Experiment with all poſſible Exactneſs: I firſt prov'd the *Chalybeat* Waters, more particularly the *Spaw* Waters, by trying whether they tinged with Galls. Theſe being very good, I put part of the Waters to cold Milk; ſome I only made lukewarm, and ſome I boil'd together, in equal Proportions: But they were ſo far from affording any Curd or Coagulation, that they continu'd ſeveral Days without being ſour.

The *German* Phyſicians (on the miſtaken Notion of their being Acid) ſtrictly prohibit their Patients the Uſe of all manner of *Lacticinia*, whilſt they are in a Courſe of theſe Waters.

This Prejudice too, has prevail'd much amongſt moſt of our Water Drinkers in *England*; but I do atteſt, that I have frequently adviſ'd, in ſome Caſes, Milk to be given daily in the Evening, through a whole Courſe of Steel Waters, with good Effect: Nay, I do affirm, that ſome others could not bear the Waters without having a third Part of Milk, or more, mix'd with them, and have continu'd them ſo for many Weeks, with good Advantage: Nor do I find the leaſt Reaſon to prohibit the Uſe of Milk in a Courſe of *Bath* Waters; having been there above a Year and half, making the beſt Scrutiny I can into the Properties, Virtues, and Vices (if they have any) of thoſe Waters.

Since our Experiments diſcover that thoſe Things which are of a ſweetning *Alkaliſate* Nature, do ſo very well agree with theſe Mineral Waters, it will appear by the following Experiment, that Acids do very much diſagree.

I put but one Drop of Oil of Vitriol to a large Glaſs full of ſtrong *Spaw* Waters, which before the Addition of this *Acid* did give a deep Purple to the Solution of Galls; but now would not give the leaſt Tincture, though I put in four Times as much of the Galls. From hence I conclude, that the Virtues of the *Chalybeat* Ingredients, which I take to be the Life and Soul of theſe Waters, were ſo far bound up or deſtroy'd, as to have loſt their Cordial or corroborating Faculty; and that the Bile or Gall in the Human Bowels, could not be able to ſeparate the *Chalybeat* (which are the only Medical) Particles, and mix them with the Chyle, in order to anſwer any End in Phyſic.

Let this be a Caution to thoſe that deſign to make theſe Waters paſs better by Urine, that they do not make uſe of any *Acids*; it being a common Practice to uſe Spirit of Vitriol, *Spiritus Nitri dulcis*, &c. as a Diuretick: Unleſs it ſhould ſo happen that they have a Deſign to take off, and diveſt them of their warm Cordial or altering Power, and ſo to bring them near to common Water; which, I muſt confeſs, we are forc'd to do, eſpecially in the Uſe of *Bath* Waters, in ſome hot inflammatory Caſes.

I ſhall conclude with one ſhort Experiment in Favour of our *Alkalies*; that if you put any *Alkali* Salt, volatile or fix'd, ſuch as Volatile Salt of Hartſhorn, or of *Sal Armoniac*, or fix'd Salt of *Tartar*, or Wormwood, or any other true *Alkali*, you will then deſtroy the above-nam'd Acid Spirit, recover the Virtue of the Waters, and diſpoſe them to give their Tincture as they uſed to do in their natural State.

Of the Nature *and* Virtues *of the* Pyrmont *Waters, by Dr.* F. Slare. n. 351. p. 564.

IX. Having procur'd about a Dozen Quarts of *Pyrmont* Waters this laſt Summer, I made ſome Trials with them. I found by the Taſte, that they contain'd a rich *Chalybeat* Virtue, and alſo made a very briſk and lively Impreſſion on the Palate, more grateful and ſpirituous, than the beſt *Spaw* Waters I ever taſted. The *Spaw* Waters are look'd upon as moſt excellent, if they ſparkle a little in a Glaſs; but theſe, in Summer-time, when pour'd into the Glaſs, nay, ſometimes even in the Bottle, as ſoon as the Cork was open'd, and the Air was admitted, would make a notable Ebullition, ſomewhat like bottled Cyder, though this was ſoon over; but they did yet continue their ſmart and briſk Taſte, and highly *Chalybeat* Reliſh, to the laſt Drop, though we were ſome Hours in drinking them off. In the Winter-time, theſe Waters do not ſparkle, nor ferment, at leaſt mine did not; but they were not carefully preſerv'd, being expos'd in cold Cellars; and yet, notwithſtanding, they loſt not the *Chalybeat* Taſte, and alſo retain'd a very pleaſant briſk Guſt. Theſe Waters have been reckon'd in the Number of the *German Acidulæ*, and ſome of my Friends, to whom I gave a Glaſs of the Water, have aſcrib'd to it a ſharp Taſte, and have been ready to run away with a poſſeſs'd Opinion of its being ſour: But, when I have deſir'd them to conſider, they have own'd that the ſmart and briſk Taſte miſled them to call it Acid or truly ſour: Thus Cyder and ſoft Ale, when bottled, will give ſuch an acute Affection to the Palate, when it is far from being ſour: And even *Volatile Alkalies* of *Sal Armoniac*, or of Hartſhorn, may be made to give the like Pungency to the Tongue.

In order to a more nice Enquiry, whether any Acidity were diſcoverable in theſe *Pyrmont* Waters, we dropp'd in conſiderable Quantities both of Spirit of Hartſhorn, and of Spirit of *Sal Armoniac*, both juſtly prepar'd; but could not diſcover the leaſt Luctation or Motion to appear upon this Conjunction, as it uſually does with an Acid.

I made a yet more nice and certain Examen of theſe Waters, by mixing Milk with them, ſometimes in equal, ſometimes in double Proportion; and in various Degrees of Warmth, both in lukewarm Degrees, and alſo with a boiling Heat, but I could not perceive any Curdling. But rather, on the contrary, the Water preſerv'd the Milk from Coagulation, for four or five Days, even in *September*, it being hot Weather.

Take a very little Gall in Powder, about half a Grain to a Glaſs of a Quarter of a Pint; this does in a Moment render it turbid, and make a dark Purple, eſpecially if you ſtir it: But if you drop the Powder on the Surface of the ſame Water, it then cauſes a fine blue Tincture. If you will make a very fine Tincture pleaſant to the Eye, take five Leaves of ſtrong Green Tea, put them into the Bottom of a Glaſs holding a Quarter of a Pint, and you will ſee thoſe Leaves unfold themſelves, and in a Quarter of an Hour, tinge the Water with ſuch a ceruleous Azure Blue, that few Vegetables do afford the like. We obſerve, that the longer theſe Leaves, or any other Stiptics, (which are the Precipitators) do ſtay together, the more they degenerate into a deep Purple, or even to an Atramentarious Colour.

In reference to the internal Uſe of theſe Waters, I drank about a Quart at a Time, after this Manner: I firſt began with the *Spaw* Waters, which I procur'd very good, and drank them for a Week, and they agreed very well. I then drank the *Pyrmont* Waters for three or four Days, and continu'd the Uſe of theſe Waters alternately, until I had drank about twenty Days. By the Reſult of my Experiment, it ſeem'd to me very plain, that the *Pyrmont* Water was more agreeable, gave more Strength and Spirit, and was as much or more preferable for its internal Virtue, as for its excelling the other in a briſker and more ſprightly Taſte.

There is another Excellency in theſe Waters, which will make them more uſeful to us, than any foreign *Chalybeat* Waters we yet know, becauſe theſe will keep better; they are not ſo ſoon ſpoil'd by any accidental Inſinuations of Air, as the *Spaw* are ſubject to be. The *Chalybeat* Mineral is here throughly diſſolv'd and well united, and mix'd in this Water, ſo that it does not eaſily precipitate: For which Reaſon, it may alſo the better paſs the *vaſa lactea*, and even enter into the Maſs of Blood it ſelf, and work the more conſiderable Effects. That this is not a bare Hypotheſis, may be prov'd by this Experiment.

Having ſuffer'd the *Spaw* Water to be expoſed in a Bottle which was half full, and unſtopp'd twelve Hours, I examin'd it, and found it taſte juſt like common Water; but the *Pyrmont* Waters that were open'd to the Air after the ſame Manner, taſted ſtrong of the Mineral, and gave their Tincture as at firſt; nay, they continu'd thus for full two Days, and perhaps might have done ſo longer, but I thought that Time ſuffic'd.

An Additional Account. Ibid.

Having had lately ſome Diſcourſe about a *Purging* Quality contain'd in theſe Waters, I am now inquiring whether they in Reality do contain any purging Ingredients or Properties.

I evaporated about a Quart of this Water *ad ſiccitatem*; I then poured on the *Reliquiæ* ſome Rain-Water, enough to diſſolve and take up the Salts, and exhal'd that Water, and had a Grain or two of the Salts, that taſted *Muriatic*, ſuch as moſt River and Pump Waters give. It is well known that the Purging Waters have a very bitter Taſte, and by Dr. *Grew*, that Salt was call'd *Sal Catharticum amarum*, which diſtinguiſh'd it from all other Species of natural Salts: That of the *Pyrmont* Water above-mentioned has no Relation to this, but to the Sea Salt, not being in the leaſt bitter.

It is alſo well known, that unleſs our Waters be impregnated with a conſiderable Quantity of this bitter Salt, it will not purge at all: Two or three Grains ſignify nothing, nor have the leaſt Cathartic Power. For Example, put two Drachms of the purging Salts to a Quart of common Water; and this Quantity will give but a Stool or wo to one who is naturally very eaſy to work upon. I have examin'd ſeveral other *Chalybeat* Waters, and found much the like Ingredients, and never any that I could ſuſpect to carry any purging Properties.

I think we can much better demonſtrate that the *Chalybeat* Waters do contain Stiptic and Reſtringent Virtues, becauſe they owe their birth to the *Iron Mineral*, and more particularly to the *Pyrites*, which Dr. *Liſter* ſuggeſts, (not without ſome Reaſon) to be the Parent even f all *Iron Ores*, as it is doubtleſs the Cauſe of all *Chalybeat* Waters: Thus I have often examin'd the Solution of the *Pyrites* by the Rain-Water at *Deptford*, and at other Places, where *Copperas* is made, nd found it a very ſtrong *Chalybeat* Water. It is from this *Mineal* we have our ſtrong Stiptic and conſtringent Medicines, for external nd internal Uſe; we have our Powders and Salts of *Steel*, or *Vitriol* f *Mars*, from hence; nay, even obſtinate and inveterate *Diarrhœas* ave, by a judicious Uſe of *Tunbridge* and other Iron Waters, receiv'd Cure.

But it is aſſerted that the Waters really do purge at *Pyrmont*, where ey are drank.

This we do allow to be true, that *Tunbridge* Waters do not only urge, but ſometimes vomit, when drank haſtily and in great Quantity; but our Phyſicians have corrected this Irregularity, and e hear of no ſuch Complaints, where they obſerve a juſt *Regimen*:

And we do all agree, that thoſe Waters are, in their own Nature, binding, and do oft require ſome opening Medicine. The Quantities of Water drank at *Pyrmont* are very large, often two or three *Engliſh* Quarts. It is no Wonder that their Weight forces them through the Bowels; for any common Water, drank haſtily, and in ſuch Quantity, will do the ſame. Whereas, if you take this Method, and will drink *Pyrmont*, or any other *Chalybeat* Waters leiſurely, *viz.* a Pint-Glaſs in an Hour, or rather two Half-Pint Glaſſes, you may drink three Pints in ſo many Hours without Danger of loſing them by Dejection. But if any one will be careful, and take this Caution with him, he will ſcarce fail of Succeſs; that is, let him be very quiet and ſtill, both in Body and Mind; the leſs he ſtirs or walks, the better he will paſs off his Waters by Urine.

I ſhall mention only one Obſervation more, which is, that none of our *Engliſh* Steel Waters do ſtrike ſuch a Purple as the foreign celebrated *Chalybeat* Waters do; for ours do give a more turbid and dark Colour, and the worſe the Waters are, the blacker Sediment they make: Thoſe of *Iſlington* abound with a coarſe *Oker*, the Mineral is not well diſſolv'd, but gives an *atramentarious* Colour; but the *Pyrmont* Waters excel all I have happen'd to examine, in its bright *Ceruleous* Luſtre.

N. B. *Moſt of the Experiments alledg'd by Dr.* Slare, *in the foregoing Diſcourſe, were likewiſe by him ſhewn before the* Royal Society, Feb. 28. 1717, *and it was found that the* Pyrmont *Waters gave a much brighter Tincture with Galls and Tea, and had a much more exalted* Chalybeat *Taſte than the* Spaw; *and a ſmall Quantity of each being kept for ſome Time in Bottles, to compare them, the* Pyrmont *was found to have retain'd its Virtues much better than the* Spaw. *The Preſident, and ſeveral of the Members preſent, having drunk a Glaſs of it, found it of a very agreeable Reliſh, and to ſit eaſy on the Stomach.*

X. *Accounts of Books Omitted.*

n. 276. p. 1038. 1. *Aloyſii Ferdinandi* Comit. *Marſigli Danubialis Operis Prodromus,* Ad Regiam Societatem *Anglicanam.* Folio 1700.

n. 308. p. 2346. 2. Dr. *Ehm*'s Treatiſe of St. *George*'s Bath by *Landeck*, in the Lordſhip of *Glats* near *Sileſia.*

CHAP. III.

Mineralogy.

1. THE Marble for this Purpoſe ought to be very ſmooth without any Spot, and hard, that it may better bear the Force of the Fire, and therefore Alabaſter is by no means proper for theſe Uſes.

The Way of Colouring Marble, *by* —— n. 268. p. 735.

2. Fire is requiſite to open the Pores, but in ſuch a Degree as that it ſhall not be ſcorched, for then the Colours will be deſtroyed; neither muſt it be too cool, for then, though it receives the Colours, yet they will be leſs fixed. For Marble even when it is cold, will imbibe ſome Colours, as Saffron, and Stone-blue for a blue Colour; but theſe Colours are eaſily diſſipated by the leaſt Heat of the Fire: And therefore the Degree of Heat ought to be ſufficient, gently to boil the Liquor that is poured upon the Marble.

3. The Menſtrua are different, according to the Diverſity of the Stuff to be diſſolved, a Lixive of Horſe's Urine made with four Parts of Pot-aſh, and one Part of Quick-lime, (*N. B.* Dog's Urine is better than Horſe's) Alſo Spirits of Wine, common Lixive, Wine and ſome oleagenous Bodies mixed.

4. The Colours laid on with a Vehicle are theſe. 1. *Stone-blue*, diſſolved in Spirit of Wine, or a Lixive of Quick-lime. 2. Lackmus in common Lixive. 3. Saffron or *Sapgreen* diſſolved in a Lixive of Urine and Quick-lime, or in Spirit of Wine. 4. Vermilion or Cochineal diſſolved as above. 5. Dragon's Blood diſſolved in Spirit of Wine according to Art. 6. Braſil Wood diſſolved in Spirit of Wine. 7. Alkanet Root extracted with the Oil of Turpentine; for it cannot be diſſolved in any other Menſtruum, neither in Spirit of Wine, nor a Lixive. 8. *Sapgreen the leſs*, mixed and diſſolved in Spirit of Wine, or a Lixive of Quick-lime as before. There is another kind of Dragon's Blood, called the Tears of it, which being mixed with Urine, produces a beautiful enough Colour, but it is hard to be got. Thoſe Colours that are mixed with Urine anſwer the beſt.

5. The Colours which are rubbed on without any Vehicle are theſe. 1. Dragon's Blood very well purified, for a red Colour. 2. Gum Gutta, for a yellow Colour. 3. Green Wax, for a green Colour. 4. Sulphur, Pitch, and Turpentine, for a brown Colour; it is only required that the Marble be ſufficiently hot, and ſo the earthy Colours are communicated to it by rubbing, which you will find by Experience.

Theſe Colours are either eaſily or difficultly waſhed out. The red Colour may be extracted in ſix and twenty Hours, with Oil of Tartar by Deliquium, without hurting the Poliſh of the Marble in the leaſt; and the brown with Aqua fortis in a Quarter of an Hour, but the Poliſh will be hurt.

For a Golden Colour, take Sal Armoniac, white Vitriol, and Verdigreaſe, and reduce them to a very fine Powder.

Of a Quarry of Marble *in* Ireland. *by Mr.* F. Nevile. n. 337. p. 278.

II. I was lately with Mr. *Cole* in the Mountains in the County of *Fermanagh* in *Ireland*, where I had diſcover'd a Marble Quarry. The Country wherein it lies, is ſo ſtrange for the natural Wonders in it, that it would make a little Hiſtory to deſcribe all that is to be ſeen: It lies on the North-ſide of *Calcagh*, in the Pariſh of *Kilaſher*, in the County of *Fermanagh*. There are Marble-Rocks, whoſe perpendicular Height is 50 or 60 Feet, diſcover'd by ſubterraneous Rivers, which by Degrees have waſh'd away the Earth and looſe Stones, and diſcover'd theſe mighty Rocks. There are many great Pits fallen in on the Sides of the great Mountain; ſeveral of them in a ſmall Compaſs of Ground, ſo that it is dangerous travelling near them. There are many Caves form'd, ſome very large, the Sides and Arches of Marble, ſome of a Liver-Colour, varied in white with many little Figures; ſome of a light blue varied with white; but I could find no entire black and white amongſt them.

An Account of a Colliery blown up; *by* —— *Communicated by Dr.* A. Charlett. n. 318. p. 215.

III. On the 18*th* of *Auguſt* 1708, at *Fatfield*, in the Pariſh of *Cheſter Le Street*, about Three of the Clock in the Morning, by the ſudden Eruption of a violent Fire, which diſcharged itſelf at the Mouths of three Pits, with as great a Noiſe as the firing of Cannon, or the loudeſt Claps of Thunder, threeſcore and nine Perſons were deſtroyed in one Inſtant. Three of them, *viz.* two Men and a Woman, were blown quite up from the Bottom of the Shaft, fifty-ſeven Fathom deep, into the Air, at a conſiderable Diſtance from the Mouth of the Pit: One of the Men with his Head almoſt off, and the Woman with her Bowels hanging about her Heels.

The Engine, by which the Coals were drawn up, and is of a great Weight, was removed and caſt aſide by the Force of the Blaſt; and what is more wonderful, the Fiſh which were in the Rivulet, that runs twenty Yards under the Level, and at as great a Diſtance from the Mouth of one of the Pits, were in great Numbers taken up dead, floating upon the Water: Whether this happen'd by the violent Concuſſion of the Air, or whether they were choaked with the Sulphur (that to be ſure in Abundance diſperſed itſelf abroad) I leave to others to determine; only this I obſerve, that for ſeveral Days a very ſtrong and noiſome Smell continued to come out of the Pits.

As to the Cauſe of it, it is to be premiſed, that Coal Mines are in general ſubject to *Stith* or *Sulphur*.

Stith, as vulgarly ſo called by the Pitmen, I think corruptly, from Stench or Stink, is a want of Air, or rather ſuch a Foulneſs in the Air, that overcomes the Spirits of the Men, and ſo ſuffocates them, as well as extinguiſhes the Candles.

Sulphur differs in this, that as the other ſuffers not the Candles to burn, this makes them burn too faſt; and the Flame by the impulſive Quality of the Air, or attracted by the Sulphur, extends itſelf upwards into a prodigious Length, and as a Match lighted for the Diſcharge of a Cannon, as ſpeedily ſets on Fire that Vapour, equally deſtructive.

Now to prevent both theſe Inconveniencies, the Viewer of the Works takes the beſt Care he can to preſerve a free Communication of Air through all the Works; that as the Air goes down one Pit, it ſhould aſcend another; but it happen'd in this Colliery, that there was a Pit which ſtood in an Eddy, where the Air had not always a free Paſſage, and which in hot and ſultry Weather was very much ſubject to Sulphur: And it being then the Middle of *Auguſt*, and ſome Danger apprehended from the Cloſeneſs and Heat of the Seaſon, the Men were withdrawn from their Work in that Pit, and turned into another; but an Overman, ſome Days after this Change, and upon ſome Notion of his own, being induced, as is ſuppoſed, by a freſh, cool, froſty Breeze of Wind, which blew that Morning, and which always clears the Works of all Sulphur, had gone too near this Pit, and had met the Sulphur juſt as it was purging and diſperſing it ſelf; upon which the Sulphur immediately took Fire by his Candle, and ſo he proved the Occaſion of the Loſs of himſelf and ſo many Men, and of the greateſt Fire that ever was known in theſe Parts.

IV. 1.] The Eruptions of Mount *Veſuvius* happen ſo frequently, that that they are almoſt innumerable, and there is not a Month paſſes, far leſs a Year, when there is not ſome deſtructive Commotion in it, ſometimes greater, and ſometimes leſs. But in 1707, there happened a very great Eruption of it, in which there were many Things obſerved which have not been taken Notice of in any other neither before nor ſince.

An Account of the Eruption *of Mount* Veſuvius *in* 1707. *by the Honourable* J. Valetta. n. 337. p. 22.

In the Year 1707, when the Weather was very hot, in the latter End of *July*, Mount *Veſuvius*, which had remained quiet for a good while, began to give ſome Signs of an approaching Commotion, for firſt there were internal Roarings heard in the Middle of the Mountain; but as yet there was no Appearance neither of Smoak nor Flame. After theſe Sounds it began gradually to ſend out Smoak and Flame, which in the Night time eſpecially ſhone over all *Campania*. In the mean time at different Intervals, it ſent out ſuch dreadful Exploſions as are hardly to be imitated by the largeſt Artillery. After this it continued to throw up Aſhes, as of ſome Stuff that had been powdered, toſſing them up into the Air for ſeveral Days and Nights, and diſperſing them over the neighbouring Country, according as the Wind blew, ſometimes into the Sea, ſometimes on the *Stabian* Coaſt, ſometimes towards *Nola*, and ſometimes towards *Acerræ*. Nor muſt I neglect to mention the great Showers of Stones, which deſtroyed every Thing where they fell, even the very Cattle. Next there ruſhed out from its Mouth, as at other Times, a Torrent of Bitumen, which they call melted Gravel, which at firſt had the Appearance of a gentle Stream of Fire, moving downward only with ſuch a Celerity, as you may obſerve in melted Pitch, or other ſuch like Subſtances. This Matter, which I would compare to Glaſs made of Sand melted in the hotteſt Furnaces, in the ſame manner as Glaſs, after it had cooled by going on; acquired a ſtony Hardneſs. But it is worth while to obſerve, that the upper Surface of this Matter when it was cold, was formed into ſmall ſpongy Stones, while the lower reſembled a ſolid, broad, and very hard Flint, which has been uſed of a long time in paving the Highways; as if that which was next to the Air had imbibed ſome of its Particles, while the under Part, having no Air mixed with it, formed a very compact Maſs. But amongſt a great many Phænomena of this boiling Mountain, there were two which had not been ſeen or known for many Ages: For the third or fourth Day, it began to ſend forth Flaſhes of Lightning from its Orifice, having the ſame Appearance as thoſe which you ſee dart from the Heavens, but tortuous and ſlow, and at the ſame Time were heard Exploſions like Claps of Thunder, ſo that at firſt we were afraid that it really thundered. The Flaſhes at firſt were ſo thick and frequent, that we expected it would rain, till we underſtood that they came from the Mountain, and that the dark Clouds were not owing to the Vapours, but to the Aſhes flying ſo thick about. On the ſecond of *Auguſt*, at four in the Afternoon, the Air at *Naples* was ſo full of Aſhes, that the Sun's Rays being excluded, there was univerſal Darkneſs, and to ſuch a Degree, that we could not know our Friends and Acquaintances in the Streets. No Night was ever darker than that Day; for if any one went abroad with a Torch, he was obliged to return again, which happened only in the Time of *Titus* as *Xiphilinus* informs us. The Magiſtrates of the City and the Prieſts, ordered Supplications to be put up by the People, and that the Relicks of St. *Januarius* the tutelar Saint of *Naples*, ſhould be carried in Proceſſion with the uſual Ceremony to the *Capuan* Gate, which is towards the Mountain. After they had got there, in the Midſt of the thickeſt Darkneſs, at length about the firſt or ſecond Hour of the Night, one or two Stars began to ſhine towards the North, where perhaps the Aſhes did not fly ſo thick, and the blue Sky to appear, and after that the Darkneſs which had robbed us of the Day gradually diminiſhed. Then the Aſhes were driven off from us towards the Sea. The next Day however was not quite clear, but the Air was ſtill ſomewhat obſcured with the Aſhes, and retained-----*dubiæ diſcrimina Lucis.*

Thus *Veſuvius* laying waſte the Country with Aſhes, exhauſted with throwing up melted Gravel for ſeveral Days, ſo that the black Torrent iſſuing out from it reached almoſt to the Sea; at laſt after fifteen Days almoſt became ſettled, and the People about *Naples* who had fled, returned Home. The Inhabitants too of the Town being at laſt freed from Fear, and deſirous to perpetuate the Memory of St. *Januarius*, who aſſiſts them always in Straits, ordered a Gold and Silver Medal to be ſtruck, on one Side of which was the Head of St. *Januarius*, with this Inſcription, DIVO JANUARIO LIBERATORI URBIS FUNDATORI QUIETIS; and on the Reverſe was *Veſuvius* quieted, and the following Inſcription, POSTQUAM COLLAPSI CINERES ET FLAMMA QUIEVIT, CIVES NEAP. INCOLUMES. MDCCVII.

—of Mount Veſuvius, *and its* Eruptions *in* 1717. *by Mr.* E. Berkeley. n. 354. p. 708.

2.] *April* 17, 1717, with much Difficulty I reach'd the Top of Mount *Veſuvius*, in which I ſaw a vaſt Aperture full of Smoak, which hinder'd me from ſeeing its Depth and Figure. I heard within that horrid Gulph, certain odd Sounds, which ſeem'd to proceed from the Belly of the Mountain; a ſort of Murmuring, Sighing, Throbbing, Churning, Daſhing (as it were) of Waves, and between whiles a Noiſe like that of Thunder or Cannon, which was conſtantly attended with a Clattering, like that of Tiles falling from the Tops of Houſes in the Streets. Sometimes, as the Wind chang'd, the Smoak grew thinner, diſcovering a very ruddy Flame, and the Jaws of the Pan or *Crater*, ſtreak'd with Red, and ſeveral Shades of Yellow. After an Hour's Stay, the Smoak being mov'd by the Wind, gave us ſhort and partial Proſpects of the great Hollow, in the flat Bottom of which, I could diſcern two Furnaces almoſt contiguous; that on the Left ſeeming about three Yards in Diameter, glow'd with red Flame, and threw up red-hot Stones with a hideous Noiſe, which, as they fell back, cauſed the before-mention'd Clattering. *May* 8, in the Morning, I aſcended to the Top of *Veſuvius* a ſecond Time, and found a different Face of Things. The Smoak aſcending upright, gave a full Proſpect of the *Crater*, which, as I could judge, is about a Mile in Circumference, and an hundred Yards deep. A conical Mount had been formed ſince my laſt Viſit, in the Middle of the Bottom. This Mount, I could ſee, was made of the Stones thrown up and fallen back again into the *Crater*. In this new Hill remained the two Mouths or Furnaces already mention'd, that on our Left-hand was in the *Vertex* of the Hill which it had form'd round it, and raged more violently than before, throwing up every three or four Minutes, with a dreadful Bellowing, a vaſt Number of red-hot Stones, ſometimes in Appearance above a Thouſand, and at leaſt three hundred Feet higher than my Head, as I ſtood upon the Brink. But there being little or no Wind, they fell back perpendicularly into the *Crater*, increaſing the conical Hill. The other Mouth to the Right, was lower in the Side of the ſame new-form'd Hill. I could diſcern it to be fill'd with red-hot liquid Matter, like that in the Furnace of a Glaſs-Houſe, which raged and wrought as the Waves of the Sea, cauſing a ſhort abrupt Noiſe, like what may be imagin'd to proceed from a Sea of Quickſilver claſhing among uneven Rocks. This Stuff would ſometimes ſpew over, and run down the convex Side of the conical Hill, and appearing at firſt red-hot, it changed Colour, and harden'd as it cool'd, ſhewing the firſt Rudiments of an Eruption, or, if I may ſo ſay, an Eruption in Miniature. Had the Wind driven in our Faces, we had been in no ſmall Danger of ſtifling by the ſulphureous Smoak, or being knock'd on the Head by Lumps of melted Minerals, which we ſaw had ſometimes fallen on the Brink of the *Crater*, upon thoſe Shots from the Gulph at Bottom. But as the Wind was favourable, I had an Opportunity to ſurvey this odd Scene for above an Hour and a half together; during which, it was very obſervable, that all the Volleys of Smoak, Flame, and burning Stones, came only out of the Hole to our Left, while the liquid Stuff in the other Mouth wrought and overflow'd, as hath been already deſcribed. *June* 5, after a horrid Noiſe, the Mountain was ſeen at *Naples* to ſpew a little out of the *Crater*. The ſame continued the 6*th*. The 7*th*, nothing was obſerv'd till within two Hours of Night; when it began a hideous bellowing, which continued all that Night, and the next Day till Noon, cauſing the Windows, and, as ſome affirm, the very Houſes in *Naples* to ſhake. From that Time it ſpew'd vaſt Quantities of molten Stuff to the South, which ſtream'd down the Side of the Mountain, like a great Pot boiling over. This Evening I returned from a Voyage through *Apulia*, and was ſurprized, paſſing by the North-ſide of the Mountain, to ſee a large Quantity of ruddy Smoak lie along a huge Tract of Sky over the River, of molten Stuff, which was itſelf out of Sight. The 9*th*, *Veſuvius* raged leſs violently; that Night we ſaw from *Naples* a Column of Fire ſhoot between whiles out of its Summit. The 10*th*, when we thought all would have been over, the Mountain grew very outrageous again, roaring and groaning moſt dreadfully. One cannot form a juſter Idea of this Noiſe, in the moſt violent Fits of it, than by imagining a mix'd Sound made up of the raging of a Tempeſt, the Murmur of a troubled Sea, and the Roaring of Thunder and Artillery, confuſed all together. It was very terrible as we heard it in the further End of *Naples*, at the Diſtance of above twelve Miles. This moved my Curioſity to approach the Mountain. Three or four of us got into a Boat, and were ſet aſhore at *Torre del Greco*, a Town ſituate at the Foot of *Veſuvius* to the South-weſt, whence we rode four or five Miles before we came to the burning River, which was about Midnight. The Roaring of the *Volcano* grew exceeding loud and horrible as we approach'd. I obſerved a Mixture of Colours in the Cloud over the *Crater*, green, yellow, red and blue; there was likewiſe a ruddy diſmal Light in the Air over that Tract of Land where the burning River flow'd; Aſhes continually ſhower'd upon us all the Way from the Sea-Coaſt. All which Circumſtances, ſet off and augmented by the Horror and Silence of the Night, made a Scene the moſt uncommon and aſtoniſhing I ever ſaw; which grew ſtill more extraordinary, as we came nearer the Stream. Imagine a vaſt Torrent of liquid Fire rolling from the Top down the Side of the Mountain, and with irreſiſtible Fury bearing down and conſuming Vines, Olives, Fig-trees, Houſes; in a Word, every Thing that ſtood in its Way. This mighty Flood divided into different Channels, according to the Inequalities of the Mountain. The largeſt Stream ſeemed half a Mile broad, at leaſt, and five Miles long. I walked ſo far before my Companions, up the Mountain, along the Side of the River of Fire, that I was obliged to retire in great Haſte, the ſulphureous

Stream having ſurprized me, and almoſt taken away my Breath. During our Return, which was about three a-Clock in the Morning, we conſtantly heard the Murmur and Groaning of the Mountain, which between whiles would burſt out into louder Peals, throwing up huge Spouts of Fire and burning Stones, which falling down again, reſembled the Stars in our Rockets. Sometimes I obſerv'd two, at others three diſtinct Columns of Flame, and ſometimes one vaſt one, that ſeemed to fill the whole *Crater*. Theſe burning Columns, and the fiery Stones ſeemed to be ſhot 1000 Feet perpendicular above the Summit of the *Volcano*. The 11*th* at Night I obſerved it from a Terraſs in *Naples*, to throw up inceſſantly a vaſt Body of Fire, and great Stones to a ſurprizing Height. The 12*th* in the Morning, it darken'd the Sun with Aſhes and Smoak, cauſing a ſort of Eclipſe. Horrid Bellowings this and the foregoing Day were heard at *Naples*, whither Part of the Aſhes alſo reached. At Night I obſerved it throw up Flame, as on the 11*th*. On the 13*th*, the Wind changing, we ſaw a Pillar of black Smoak ſhot upright to a prodigious Height. At Night I obſerved the Mount to caſt up Fire as before, tho' not ſo diſtinctly becauſe of the Smoak. The 14*th*, a thick black Cloud hid the Mountain from *Naples*. The 15*th* in the Morning, the Court and Walls of our Houſe in *Naples* were cover'd with Aſhes. In the Evening, Flame appear'd on the Mountain through the Cloud. The 16*th*, the Smoak was driven by a Weſterly Wind from the Town to the oppoſite Side of the Mountain. The 17*th*, the Smoak appear'd much diminiſh'd, fat and greaſy. The 18*th*, the whole Appearance ended, the Mountain remaining perfectly quiet without any viſible Smoak or Flame. A Gentleman, whoſe Window look'd toward *Veſuvius*, aſſur'd me, that he obſerv'd this Night ſeveral Flaſhes, as it were of Lightning, iſſue out of the Mouth of the *Volcano*. I ſhall not mention the Conjectures I have formed concerning the Cauſe of theſe *Phænomena*, from what I obſerved in the *Lacus Amſancti*, the *Solfatara*, *&c.* as well as in Mount *Veſuvius*. But this I may ſay, that I ſaw the fluid Matter riſe out of the Center of the Bottom of the *Crater*, out of the very Middle of the Mountain, contrary to what *Borelli* imagines, whoſe Method of Explaining the Eruption of a *Volcano* by an inflexed Siphon, and the Rules of *Hydroſtatics*, is likewiſe inconſiſtent with the Torrents flowing down from the very *Vertex* of the Mountain.

V. On the 28*th* of *December* 1703, there happen'd an Earthquake in theſe Parts. From *Hull* I am inform'd, that it was felt about three or four Minutes after five in the Evening; that it heav'd up Chairs and Tables, made Pewter-Diſhes and the Windows rattle, ſhook whole Houſes, and threw down Part of a Chimney. The Shock came and went ſuddenly, and was attended with a Noiſe like the Wind, though there was then a perfect Calm.

An Account of an Earthquake *in the* North *of* England, 1703. *by Mr.* R. Thoreſby. n. 289. p. 1555.

It was felt in much the ſame Manner at *Beverly* and other Places, and particularly at *South-Dalton*. It was more violent near *Lincoln*, where it heav'd up the Chairs; and, as a certain Clergyman informed me, ſhook every Limb of him. At *Selby* it was felt pretty much; as alſo near *Navenby*, where the Noiſe which preceded it ſeemed to ſome like the Rumbling of two or three Coaches driven furiouſly, and immediately the Chairs they ſat on were ſhook violently, and the very Stones were ſeen to move.

Of Trees *found under* Ground *in* Hatfield-Chace, *by Mr*. Abr. de la Pryme. n. 275. p. 980.

VI. 1.] The Levels of *Hatfield-Chace* in *Yorkſhire*, were the greateſt Chace of red Deer that King *Charles* the Firſt had in all *England*; containing in all Limits above 180000 Acres, about half of which was yearly drowned and ſurrounded with an Ocean of Waters. This he bargains with, and ſells to one Sir *Cornelius Vermuiden*, a *Dutchman*, to diſchace, drain, and reduce to Arable and Paſture Land; which to the Surprize of all, and to the great Advantage of the Country round it, he at length effectually perform'd at the Expence of above 400000 Pounds.

In the Soil of all, or moſt of theſe 180000 Acres of Land (of which 90000 were drained) even in the Bottom of the River of *Ouſe*, in the Bottom of the adventitious Soil of all *Marſhland*, and round about by the Skirts of the *Lincolnſhire* Woolds unto *Gainſburg*, *Beautry*, *Doncaſter*, *Baln*, *Snaith*, and *Holden*, are found infinite Millions of the Roots and Bodies of Trees, great and little, of moſt of the Sorts, that this Iſland either formerly did, or at preſent does produce, as Firs, Oaks, Birch, Beech, Yew, Wirethorn, Willow, Aſh, &c. the Roots of all, or moſt of which ſtand in the Soil in their natural Poſtures, as thick as ever they could grow, as the Bodies of moſt of them lie by their proper Roots. Moſt of the great Trees, by all their Length about a Yard from their great Roots (unto which they did moſt evidently belong, both by their Situation and the Sameneſs of the Wood) with their Tops commonly North-Eaſt, though the ſmaller Trees lie almoſt every Way croſs thoſe, ſome above, ſome under, a third Part of all which are Firs, ſome of which have been found of thirty Yards length and above, and have been ſold to make Maſts and Keels for Ships. Oaks have been found of 20, 30 and 35 Yards long, yet wanting many Yards at the ſmall End. Some of which have been ſold for 4, 8, 10 and 15*l*. a-piece; which are as black as Ebony, and very laſting and durable. The Aſhes are as ſoft as Earth, and are commonly cut in Pieces by the Workmens Spades, which as ſoon as flung up into the open Air, fall away into Duſt; but all the reſt, even the Willows themſelves, which are ſofter than Aſhes, preſerve their Subſtance and Texture to this Day. I have ſeen ſome Fir-Trees, that as they have laid all along, after that they were fallen, have ſtruck up great Branches from their Sides, which have grown into the Thickneſs and Height of conſiderable Trees.

It is very obſervable, and manifeſtly evident, that many of thoſe Trees of all ſorts have been burnt, but eſpecially the Fir-Trees, ſome quite through, and ſome all on a Side, ſome have been found chopp'd and ſquared, ſome bored through, others half riven with great wooden Wedges, and Stones in them, and broken Ax-heads, ſomewhat like Sacrificing Axes in Shape; and all this in ſuch Places, and at ſuch Depths, as could never be opened from the Deſtruction of this Foreſt until the Time of the Drainage. Near a great Root in the Pariſh of *Hatfield*, were found 8 or 9 Coins of ſome of the *Roman* Emperors, but exceedingly conſumed and defaced with Time; and it is obſervable, that upon the Confines of this low Country, between *Burningham* and *Brumby* in *Lincolnſhire*, are ſeveral great Hills of looſe Sand, under which (as they are yearly worn and blown away with the Sand) are diſcovered many Roots of great Firs, with the Impreſſes of the Ax as freſh upon them, as if they had but been cut down a few Weeks; which I have ſeveral Times taken Notice of.

Hazle Nuts and Acorns have frequently been found at the Bottom of the Soil of thoſe Levels and Moors, and Fir-Tree Apples, or Cones, in great Quantities, by whole Buſhels together. And at the very Bottom of a new River or Drain, that the Drainers cut, (almoſt 100 Yards wide, and 4 or 5 Miles long, at the Charge of above 30000 *l.* beſides the great Sluice at the End thereof, which coſt near 30000 *l.* more) were found old Trees ſquared and cut, Rails, Stoups, Bars, old Links of Chains, Horſe-heads; an old Ax, ſomewhat like a Battle-Ax, two or three Coins of the Emperor *Veſpaſian*; one of which I have ſeen, with the Emperor's Head on the one Side, and a Spread Eagle on the other; but that which is more obſervable, is, that the very Ground at the Bottom of the River was found in ſome Places to lye in Rigg and Fur, manifeſting thereby that it had been plow'd and tilled in former Days.

Mr. *Edw.* *Canby* told me, that about 50 Years ago, under a great Tree in this Pariſh, was found an old-ſhaped Knife, with a Haft of a very hard black ſort of Wood, which had a Cap of Copper or Braſs on the one End, and a Hoop of the ſame Metal on the other End, where the Blade went into it; which Blade ſoon mouldering away, he got a new Blade put therein, with this Diſtich upon it,

Ever ſince No'*s Flood was I left,*
My old Blade's conſum'd, but this is the Haft.

The ſame Gentleman alſo found an Oak Tree within his Moors 40 Yards long, 4 Yards in Diameter at the great End, 3 Yards and a Foot in the Middle, and two Yards over at the ſmall End; ſo that the Tree ſeems to have been as long again; for which he was proffer'd 20 *l.* At another Time he found a Fir-Tree 36 Yards long, beſides the computed Length thereof, which might well be 15 Yards more. About 50 Years ago, at the Bottom of a Turf-pit, was found a Man lying at his length, with his Head upon his Arm, as in a common Poſture of Sleep, whoſe

Skin being as it were tann'd by the Moor-Water, preſerved his Shape intire, but within, his Fleſh and moſt of his Bones were conſumed and gone; an Arm of whom is now in the Poſſeſſion of Dr. *Nat. Johnſon.*

Though theſe Things may ſeem ſtrange, yet many Authors have related the ſame.

Cambden and others have told us, and it is a Thing well known, that moſt of the great Moraſſes, Moſſes, Fens and Bogs in *Somerſetſhire, Cheſhire, Lancaſhire, Weſtmoreland, Yorkſhire, Staffordſhire, Lincolnſhire,* and other Counties in *England,* are full of the Roots and Bodies of great Trees, moſt of which are Fir; and that they have the ſame Poſitions and Impreſſions of the Fire and Ax upon them, that thoſe have.

Giraldus Cambrenſis tells us, that in King *Henry* the Second's Days, by the Force of extraordinary Storms, the Sands were driven ſo much off from the Sea-ſhores, in *Pembrokeſhire,* that under them were diſcovered great Numbers of the Roots and Bodies of Trees in their natural Poſtures, with the Stroaks of the Ax as freſh upon them, as if they had but been cut down yeſterday, with a very black Earth, and ſome Blocks like unto Ebony; the ſame were diſcover'd again at *Neugall,* in the ſame County in 1590, and in *Cardiganſhire,* and other Places ſince.

Dr. *Plot* mentions the like Roots and Trees to be found in *Shebben* Pool, the old *Pewit* Pool, and at *Layton* and other Places in *Staffordſhire;* and from their natural Situations and Poſtures concludes, that they did certainly grow there.

Dr. *Leigh,* in his Hiſtory of *Cheſhire,* obſerves, that in the draining of *Martin Meer* (which was perform'd but a few Years ago) were found Multitudes of the Roots and Bodies of great Firs, in their natural Poſtures, with great Quantities of their Cones, 8 Canoes, ſuch as the old *Britons* ſail'd in, and in another Moor was found a Braſs Kettle, Beads of Amber, a ſmall Millſtone, the whole Head of an *Hippopotamus,* and Human Bodies intire and uncorrupted. I ſuppoſe he means, as to outward Appearance.

Many Places of the Soil of *Angleſea* and *Man,* as alſo of the Bogs of *Ireland,* are likewiſe full of Roots and Trees; but of what Sort I have not yet learn'd.

Verſtegan tells us, that in many Places of the Moors and Moraſſes of the *Netherlands,* great Fir-Trees are commonly found with their Tops lying to the North-Eaſt, juſt as they do in theſe Levels, and *Helmont* mentions the *Peel* there, a Turf Moor of 9 Miles broad.

I have likewiſe read in ſome of the *French* Naturaliſts, I think in Monſieur *de la Ferr,* that Trees and Roots are alſo frequently found in the Low Grounds, Levels and Moraſſes of *France, Switzerland* and *Savoy.*

Rammazzini aſſures us, that in the Territories of *Modena* (which are ſeveral Miles long and broad, and at preſent a moſt fruitful dry Country, tho' in the Time of the *Cæſars* it was nothing but a great Lake) are found at 30, 40, and 50 Feet deep, the Soil of a low marſhy

Country, full of Sedge, Reeds, Shrubs, Roots, Trees, Nuts, Ears of Corn, Leaves of Trees, Branches and Boughs of Oaks, Elms, Wallnuts, Aſhes, Willows, and the very Trees themſelves, ſome broke, ſome whole, ſome ſtanding upright, ſome lying at their Length, &c. with old Coins of the *Roman* Emperors, old Marbles and Stones ſquared, cut, carved, and wrought, with the Hands of Men, &c.

Moſt Men refer all this to *Noab*'s Flood; but if ſo, how comes it hat the Trees and their Roots lie ſo near to one another, and why engthways, from South-Weſt to North-Eaſt? Why ſome of them burnt, ſome chopt, ſome riven, ſome ſquared, ſome bored through? Why the Soil at the very Bottom of a great River lying in Rigg and Fur? And why the Coins of *Roman* Emperors found in thoſe Places, &c.? But I am of Opinion, that all thoſe Trees grew in the very Places where we now find them, both in this Country, and all others where hey are found; to which I have heard but two Objections: The firſt, That *Cæſar* expreſly ſays, that no Fir-trees in his Time grew in *Briain*: But that *Cæſar* may have been miſtaken in this Point, may appear rom what he mentions of the next Tree, the *Beech*, which he excludes lſo; and which is ſo common in every Part of this Nation: And in n old Deed relating to this very Chace, Fir-trees or Buſhes are menion'd as growing here and there one, about 300 Years ago; and it is very well known, that there was a Tree of the very ſame Wood growng upon *Hatfield* Moor Side within theſe 30 Years, which a while afer was cut down, it being the very laſt of that Kind that was ſeen flouriſhing here.

The ſecond Objection is, That thoſe ſorts of Trees grow always on igh Mountains and Rocks, and never thrive, nor naturally grow upon ſuch Low Grounds and Moraſſes, as theſe are, where we now find hem; but though they do indeed in all cold Countries of the North, hrive beſt there upon the hardeſt Rocks and Mountains, yet are they ſometimes ſeen even there plentiful and great, in the Low Moraſſes of *Liefland*, *Courland*, *Pomerania*, and other Countries thereabouts; and n the Low Foreſts and Woods Weſt of *New England*, as I have heard Travellers affirm, what theſe Trees require, is a ſandy Soil; and if it ie never ſo high, or never ſo low, there they will grow, and there it s natural to them. And as the Reverend Mr. *Earat* of *Hatfield* lately obſerv'd in the digging of a Pit of a great Decoy in theſe Levels, the Roots of the Firrs always ſtood in the Sand, and the Oaks in the Clay; and I have obſerved the ſame in Multitudes of Places of theſe Commons.

The Reaſon why all theſe Woods were deſtroy'd, we may learn from he *Roman* Hiſtorians; who frequently tell us, that when their Armies and Generals purſued the wild *Britons*, that they always fled into the Faſtneſſes of miry Woods and low watery Foreſts. *Cæſar* himſelf confeſſes the ſame; and ſays, that *Caſſibelan* and his *Britons*, after their Defeat, paſſed the *Thames*, and fled into ſuch low Moraſſes and Woods,

that

that there was no Poſſibility of following them. We find alſo, that the ſtout Nation of the *Silures* did the ſame when they were ſet upon by *Oſtorius* and *Agricola*. The like did *Venutius* King of the *Brigantes*, who fled into the great woody Moraſſes of this Country, and perhaps into thoſe very ſame that formerly overſpread theſe Levels. And *Herodian* tells us, that it was the Cuſtom of the wild *Britons* to keep in the fenny Bogs and thick marſhy Woods, and when Opportunity offer'd, to iſſue out, and fall upon the *Romans*, who were at length ſo plagued with them, that they were forced to iſſue out Orders for the deſtroying and cutting down of all the Woods and Foreſts in *Britain*, eſpecially of all thoſe that grew upon low Ground and Moraſſes. This Order, I think, is mention'd in *Vopiſcus*; and that they were accordingly thereupon cut down, is evident in many Writers, who tell us, that when *Suetonius Paulinus* conquer'd *Angleſea*, he cut down all the Woods there. *Galen* tells us, that the *Romans* kept their Soldiers continually employed in cutting down of Woods, draining of Marſhes and Fens, and in paving of Bogs. It is manifeſt alſo, that they did not only do this themſelves, but alſo impoſed the ſame Taſk upon the *Britons*; for *Galgacus* in his Speech to his Soldiers, tells them, that the *Romans* made Slaves of them, and wore out their Bodies in cutting down of Woods and in cleanſing of Bogs, amidſt a thouſand Stripes and Indignities; and *Dion Caſſius* tells us, that the Emperor *Severus* loſt 50000 of his Men in a few Years time, in cutting down of the Woods, and cleanſing of the Fens and Moraſſes of the Nation.

As I have ſhew'd in general, that the *Romans* were the Deſtroyers of all thoſe great Woods and Foreſts, ſo now I ſhall ſhew in particular, that they actually were in this Part of the Country, and deſtroy'd this great and beautiful Foreſt of *Hatfield-Chace*.

The common Road of the *Romans* out of the South into the North, was formerly from *Lindum* (*Lincoln*) to *Segelocum* (*Little burrow upon Trent*) and from thence to *Danum* (*Doncaſter*, where they kept a ſtanding Garriſon of *Criſpinian* Horſe) a little off on the Eaſt and North-Eaſt of their Road between the two laſt named Towns, lay the Borders of the great Foreſt, which ſwarm'd with wild *Britons*, who were continually making their Sallies out of the ſame, and their Retreats into it again, intercepting their Proviſions, taking and deſtroying their Carriages, killing their Allies and Paſſengers, and diſturbing their Garriſons; which at length ſo enraged the *Romans*, that they were reſolved to deſtroy it; and that they might do the ſame more effectually, they marched with a great Army againſt the ſame, and encamped upon a great Heath or Moor, not far from *Finningly*, (as by their Fortifications there yet to be ſeen, is apparent) where it is probable, that a great Battle enſued; for hard by, is a little Town, called *Oſterfield*. Now as the latter Part of the Word is never uſed to be added to any other, but where there hath been a Battle; ſo the former ſeems to tell us what *Roman* General it was that fought, to wit, the famous *Oſtorius*, whom all the *Roman*

Hiſtorians aſſure us, was in thoſe Parts. But who got the Victory, is not ſo eaſy to be judged of, though, no Doubt, it was the valiant *Romans*, who beſides the Multitudes of the *Britons* that they ſlew, drove the reſt back into the great Foreſt and Wood, that cover'd all this low Country: Whereupon the *Romans*, that they might both deſtroy it and the Enemy the eaſier, took the Opportunity of a ſtrong South-Weſt Wind, and ſet great Fires therein, which taking hold of the Fir-trees, burnt like Pitch, and conſumed infinite Numbers of them; then when the Fir had done what Miſchief and Execution it could, the *Romans* brought their Army nearer, and with whole Legions of captive *Britons* chopp'd and cut down moſt of the Trees, that were yet left ſtanding, leaving only here and there ſome great ones untouched, as Monuments of their Fury, and unneedful of their Labour; which being deſtitute of the Support of the Underwood, and of their neighbouring Trees, were eaſily overthrown by the ſtrong Wind; all which Trees falling croſs the Rivers that formerly ran through this Low Country, ſoon damm'd up the ſame, turned it into a great Lake, and gave Origin to the great Turf Moors that are here, by the Gyrations and Workings of the Waters, the Precipitation there-from of terreſtrial Matter, the Conſumption and Putrefaction of rotten Boughs and Branches, and the vaſt Increaſe of thick Water Moſs, which wonderfully flouriſhes, and grows upon ſuch rotten Grounds; which, even now, ſince the Drainage, and ſince that the Country is laid dry for many Miles round about, yet for all that, are ſo turgid with Water, and ſo ſoft and rotten, that they will ſcarce bear Men to walk upon them.

Hence it is, that old *Roman* Coins, old *Roman* Ax-heads, *&c.* have been found by thoſe Roots and Trees that lie at the Bottom of theſe Moors and Levels. Hence it is, that in all theſe Grounds are found great Numbers of Trees, that are burnt, ſome in two, and ſome lengthways, others hewn and chopp'd. Hence it is, that they lie by their own proper Roots with their Tops North-Eaſt: Hence it is, that ſome of the greateſt Trees are found with their Roots on, and others, as they have laid all along, have had Branches growing out of the Sides, unto the Thickneſs and Height of conſiderable Trees. Hence it is, that both the Clay and Moor Soil of the Country, is in ſome Places two or three Yards higher than it was formerly, by the growing up of the ſame, and the daily Warp that the Rivers continually caſt thereon, *&c.*

As the *Romans* were the Deſtroyers of this great Foreſt, ſo were they likewiſe of all thoſe others that formerly grew upon the Low Countries of *Cheſhire*, *Lancaſhire*, *Yorkſhire*, *Lincolnſhire*, *Staffordſhire*, *Somerſetſhire*, &c. and of the very Countries before-mention'd beyond Sea, where ſuch Trees are found. But as the *Romans* were not much in *Wales*, the *Iſle of Man*, nor *Ireland*, ſo it cannot be ſuppoſed that it ſhould be them that cut down their Woods; but though they did not, yet others did, for *Hollinſhead* and others of our Hiſtorians tell us, that *Edward* I. being not able to get near the *Welſh* to fight them, by their Continuance and Skulking in boggy Woods, commanded them all to be deſtroyed by Fire and Ax: And I doubt not at all, but that the Roots and Trees, before mention'd by *Cambrenſis* in *Pembrokeſhire*, were the Relicts of ſome of thoſe, that were then deſtroy'd: And as for thoſe in *Man*, and other Iſlands, they have all been cut down in the Time of War, and have laid till they were grown over with the Soil of the neighbouring Grounds: And as for thoſe that are found in the Bogs of *Ireland*, many of our Hiſtorians expreſly ſay, that *Henry* the Second, when he conquer'd it, cut down all the Woods that grew upon the Low Countries thereof, the better to ſecure his Conqueſt and Poſſeſſion of the ſame, to keep the Country in a ſettled Peace, and to diſarm the Enemy, who commonly truſting to ſuch Advantages, are apt to rebel.

I may alſo add, that it is a very common thing for Generals, even to this very Day, to deſtroy all the Woods that grow upon advantageous Places and Faſtneſſes in an Enemy's Country, if they intend to keep it; and that they always do it with Fire and Ax.

——*on the* ſame, *by the* ſame. n. 277. p. 1073.

2.] I have received ſome farther Informations about the *Fir-Trees* of *Hatfield-Chace*. I have been told by ſeveral Gentlemen, that about 20 Years ago, one *Sanderſon*, of *Hatfield*, died, aged near 80 Years, whoſe Father, much of the ſame Age, did frequently aſſure him, and other Gentlemen that were curious in the Matter, that he could very well remember many Hundreds of great Fir-trees, ſtanding one here and another there, in a languiſhing decaying Condition, half as high as Houſes, and ſome higher, whoſe Tops were all dead, yet their Boughs and Branches always green and flouriſhing, growing all of them in theſe Levels: And *John Hatfield* of *Hatfield*, Eſq; who is not above 40 Years of Age, has by him a large Twig that his Father pluck'd off from the Sprout of a green and flouriſhing Shrub of Fir, that grew from the great Root of one of the ſame kind in theſe Commons. And an old Man of *Croul* tells me, that he has heard his Father ſay, that he could remember Multitudes of Shrubs and ſmall Fir-trees growing here, while this Country was a Chace, and while the Vert was preſerved, before the Drainage. And in many old Charters, that I have ſeen, of *Roger de Mowbray*, Lord of *Axholm*, who lived in the Year 1100, relating to *Hurſt*, *Bell-wood*, *Roſs*, *Santoft*, &c. it appears, that then all theſe Places were cover'd with a great old decaying Foreſt or Wood; and not them only, but alſo all that low Common between *Croul* Cauſey and *Authrop upon Trent*; and though there be not one Stick of any ſuch Thing now to be ſeen, yet it is not only plainly manifeſt, that the ſame was true, from the Roots there found, but alſo from the ſaid Roots, that moſt of the Trees that then grew there, were Firs. All which were but the After-growth, and Relicts of the great Foreſt, that was deſtroyed by the *Romans*.

VII.

Of Subterraneous Trees at Dagenham *in* Eſſex, *by Mr.* W. Derham. n. 335. p. 478.

VII. There happen'd an Inundation at *Dagenham* and *Havering* in *Eſſex*, about four or five Years ago, by a Breach in the *Thames* Wall at an extraordinary high Tide; and by Means of the great Violence of the Water, a large Channel was torn up, or Paſſage for the Water of 100 Yards wide, and 20 Feet deep in ſome Places; and in ſome more, ſome leſs. By which means a great Number of Trees were laid bare, that had been there interred many Ages before.

The Trees were all of one Sort, except only one, which was manifeſtly a large Oak, with the greateſt Part of its Bark on, and ſome of its Head and Roots. The reſt of the Trees were taken to be *Yew*, from the Hardneſs, Roughneſs, and Weight of the Wood, notwithſtanding we have no *Yew* growing any where thereabouts; and it ſeem'd ſtrange to me, that *Yew* ſhould grow in ſuch vaſt Quantities, in ſuch a Soil, and ſo near the brackiſh Waters. Some took it to be *Horn-beam*, which grows plentifully alſo with us in the higher Lands (but I do not remember to have ſeen it in watery Places near us) but I rather incline to the Opinion of its being *Alder*, (which grows plentifully by our Freſh-Water Brooks) the Grain of the Wood, and Manner in which the Boughs grow, *&c.* much more reſembling that of *Alder*, than *Horn-beam*.

By lying ſo long under Ground, the Trees are become black and hard, and their Fibres are ſo tough, that one may as eaſily break a Wire of the ſame Size, as any of thoſe Fibres. This Toughneſs they maintain, if the Wood be kept dry; but by drying, thoſe Trees become cracked, and very flawy within, but look ſound outwardly, and with Difficulty yield to Wedges. But the Trees lying in the Marſhes, which are covered by every Flood, and laid bare by every Ebb, in a ſhort Time become very rotten.

There is no doubt, but thoſe Trees grew in the Place where they now lie, and that in vaſt Multitudes; they lying ſo thick upon, or near one another, that in many Places I could ſtep from one to another. And there is great Reaſon to think, that not only the Marſhes, which are now overflow'd (which are about 1000 Acres) are covered underneath with thoſe ſubterraneous Trees, but alſo all the Marſhes along by the River Side, for ſeveral Miles: For we diſcover theſe Trees all along the *Thames* Side over againſt *Rainham*, *Wennington*, *Purfleet*, and other Places: And in the Breach that happened at *Weſt Thorrock* about 21 Years ago, they were waſhed out in as great Numbers (as I have been inform'd) and of the ſame kind of Wood, as thoſe found lately in *Dagenham* and *Havering* Levels.

Theſe Trees are of different Sizes; ſome above a Foot Diameter, ſome leſs. I met with two of the leſſer Sort, ſtanding upright, in the ſame Poſture in which they grew; their Tops juſt above Low-Water, and their Bottoms (at leaſt the Bottom of the Channel) at 16 Feet Depth. We endeavoured to draw them out, but could not do it with-all our Strength. They ſeemed to be about two Inches Diameter in their Trunk, had ſome of their Boughs on, were dead, and in all Likelihood, being young and light, eſcaped the Force of what threw the other more large and unwieldy ones down.

Moſt of the Trees had their *Roots* on, and many of them their *Boughs*, and ſome a Part of their *Bark*. There was only one that I perceived had any Signs of the *Ax*, and its Head had been lopped off.

I could ſee all along the Shores vaſt Numbers of the *Stumps* of thoſe ſubterraneous Trees, remaining in the very ſame Poſture in which they grew, with their Roots running ſome down, ſome branching and ſpreading about in the Earth, as Trees growing in the Earth commonly are ſeen to do. Some of thoſe Stumps I thought had Signs of the Ax, and moſt of them were flat at top, as if cut off at the Surface of the Earth; but being rotten and battered, I could not fully ſatisfy myſelf, whether the Trees had been cut or broken off.

The *Soil*, in which all thoſe Trees grew, was a black oozy Earth, full of the Roots of Reed; on the Surface of which oozy Earth the Trees lay proſtrate, and over them a Covering of grey Mould, of the ſelf ſame Colour and Conſiſtence with the dry Sediment, or Mud, which the Water leaves behind it at this Day. This Covering of grey Earth is about 7 or 8 Feet thick, in ſome Places 12 Feet or more, in ſome leſs; at which Depths the Trees generally lie.

Another Thing I took notice of, was the *Poſture* in which the Trees lay, which was indeed in no kind of Order, but ſome this way, ſome that, and many of them a-croſs: Only in one or two Places I obſerved they lay more orderly, with their Heads for the moſt part towards the North, as if they had been blown down by a Southerly Wind, which exerts a pretty ſtrong Force upon that Shore.

As to the *Age* in which thoſe Trees were interred, it is hard to determine. Many think they have lain in that ſubterraneous State ever ſince *Noah*'s *Flood*. But although I have not the leaſt Doubt, but that at this Day we have many Remains of the Spoils of that Deluge, even in the higheſt Mountains; yet I rather think theſe Trees to be the Ruins of ſome later Age, occaſioned by ſome extraordinary Inundations of the River of *Thames*, or by ſome Storms, which blow ſharply upon this Shore: Either of which Acts of Violence might be able to root up, and tumble down Trees growing in ſo lax a Soil, as theſe manifeſtly grew in at that Time. And as for extraordinary *Inundations* of the *Thames*, there is at this Day a Mark, which, if occaſioned by an Inundation, was the Mark of an Inundation very prodigious, beyond all ever known to have been in that River; and that is a *Bed of Shells*, if not a kind of Marble too, lying croſs the Highway on the Deſcent near *Stifford-bridge*, going from *S. Okendon*.

Below this Bed of Shells, at above 50 or 60 Yards Diſtance in the Bottom of the Valley, runs a Brook that empties itſelf into the *Thames* at *Purfleet*, about three Miles from thence; which Brook ebbs and flows as the *Thames* does, but not at any certain Height, by Reaſon of Mills ſtanding thereon; but above a pretty High-water in the Brook, the Surface of the Bed of Shells I find to lie above 20 Feet perpendicular. Conſequently if this Bed of Shells was repoſited in that Place by an Inundation of the *Thames*, that Inundation muſt be ſuch, as would have drowned a vaſt deal of the adjacent Country, and have over-topped the Trees by the River, in *Weſt-Thorrock*, *Dagenham*, and the other Marſhes, and probably by that Means overturned them.

Now had theſe Trees been left there by the *Univerſal Deluge*, we ſhould not find the Bed of Earth, in which they grew, ſo entire and undiſturbed, as it manifeſtly is at this Day, a ſpongy, light, oozy Soil, full of Reed-root; and I aſſure myſelf (although I never try'd it) of much leſs ſpecific Gravity than the *Stratum* above it is. Whereas I can from Experiments affirm, that in the three Places where I have tried it, the *Strata* are in a ſurprizing Manner gradually ſpecifically heavier and heavier, the lower and lower they lie.

As for the *Manner how theſe Trees came to be interred*, this I take to be from the gradual Increaſe of the Mud, or Sediment, which every Tide of the *Thames* leaves behind it. I preſume, thoſe Trees might be thrown down before the Walls or Banks were made, that keep the *Thames* out of the Marſhes; and then thoſe Trees were over-flown every Tide. And by Reaſon they lay thick, would ſoon gather a great deal of the Sediment. And after the *Thames* Walls were made, every Breach in them, and Inundation, would leave great Quantities of Sediment behind it; as I found in going over ſome of the Marſhes, ſoon after the late Breach, where I found the Mud generally above my Shoes, and in many Places above my Knees. And it is a Practice among us (of which we have divers Inſtances) that where a Breach would coſt more to ſtop, than he Lands over-flown will countervail, there to leave the Lands to the Mercy of the *Thames*; which by gradually growing higher and high- r, by the Additions of Sediment, will in Time ſhut out the Water of he River, all except the higheſt Tides. And theſe Lands they call *Salt- ngs*, when covered with Graſs; or elſe they become *Reed-ground*, &c.

That it was the Sediment of the *Thames* that buried theſe Trees, is urther manifeſt from what I ſaid before, of the Likeneſs of the Earth bove them, in all Reſpects, to the Sediment the River now lets fall, When dry, which may be obſerved to conſiſt of many diſtinct Layers; ſome $\frac{2}{10}$ of an Inch thick, ſome leſs, and ſome ſcarce $\frac{1}{10}$ of an Inch. All which ſeveral Layers are, no doubt, the ſeveral Quantities, which very Tide left behind it. This Sediment, when dry'd by the Sun and Wind, becomes tough and hard, and looketh like a grey *Lapis Sciſſilis* *Slate*, diviſible into many Plates or Layers. And what if we ſhould cribe the Conformation of *Slate*, *Muſcovia-glaſs*, and other the like la- nated Concretions, to a like Work of Nature, by adding new Layers ſuch Petrifactions, and Particles, as the Foſſil is made of?

I preſume there will be no doubt but that the ſubterraneous Wood receives its Blackneſs from Vitriolic Juices in the Earth. I have try'd the Experiment, and find that *Alder-Wood*, whether green or old, becomes blackiſh, much of the ſame Colour as the Wood mentioned in this Paper, in a Solution of Copperas Which is not only an Argument, that the Blackneſs of the Wood is owing to Vitriol, but alſo that the Wood is *Alder*, or ſome ſuch like Wood, that will become black with Vitriol; for I am informed that all ſubterraneous Wood is not black, particularly *Fir*. I have tried *Horn-beam* ſince, after the ſame Manner, and find that alſo becomes black, as the *Alder* doth.

Of ſtrange Bones *dug up near* Canterbury. *And of the* Iſthmus *between* Dover *and* Calais, &c. *by Mr.* W. Somner. n. 272. p. 882.

Fig. 26, 27.

VIII. 1.] Mr. *John Somner*, in the Month of *September* 1688, ſinking a Well at a new Houſe of his in *Chartham*, a Village about three Miles from *Canterbury*, towards *Aſhford*, on a ſhelving Ground or Bank-ſide, within twelve Rods of the River, running from thence to *Canterbury*, and ſo to *Sandwich* Haven; and digging for that purpoſe above ſeventeen Feet deep, through gravelly and chalky Ground, and two Feet into the Springs, there met with, and turned up a Parcel of ſtrange and monſtrous Bones, ſome whole, ſome broken, together with four Teeth, perfect and ſound, but in a manner petrified, and turned into Stone; weighing (each Tooth) ſomething above half a Pound, almoſt as big (ſome of them) as a Man's Fiſt: Cheek-Teeth, or Grinders, as to the Form, they are all, not much unlike, (but for the Bigneſs) the Grinders of a Man. I remember to have read in *Ludovicus Vives*, of ſuch a Tooth, but a little bigger *(dens molaris pugno major)* which was ſhewed to him for one of St. *Chriſtopher*'s Teeth, and was kept in a Church that bore his Name. Juſt ſuch another Tooth, *of the Bigneſs*, he ſaith, *of an ordinary Fiſt*, was ſeen by *Acoſta* in the *Indies*, digged out of the Ground, in one of their Houſes there, with many other Bones; which put together repreſented a Man of a formidable, or as he ſpeaks, *deformed Bigneſs*; as he judged of it. And ſo muſt we have judged of theſe Teeth, and of the Body to which they belonged, had not other Bones have been found with them, which could not be Man's Bones. Some that have ſeen them, by the Teeth and ſome other Circumſtances, are of Opinion, that they are the Bones of an *Hippopotamus*, or *Equus Fluvialis*; that is, a *River Horſe*; for a *Sea Horſe*, as commonly underſtood and exhibited, is a fictitious Thing. Yet *Pliny* makes *Hippopotamum (mari, terræ, amni communem)* to belong to *Sea*, *Land*, and *Rivers*. But what the Differences and Properties of each Kind are, I leave to others to enquire. The Earth or Mould about them, and in which they all lay, being like a Sea-Earth, or Fulling-Earth, not a Stone in it, unleſs you dig three Feet deeper, and then it riſes a perfect Gravel.

It is not eaſy to define or determine what the Creature was; and doubtleſs dubious enough it is, whether of the two, the Sea or the Land, may more rightly lay Claim to it. But I am of Opinion, that it is ſome

Marine, or Sea-bred Creature, to which the Land can of Right lay no Claim. But ſuppoſing it a Sea-bred Creature, how then (will ſome ſay) ſhould it poſſibly come there? and at ſuch a Depth under Ground? I anſwer, firſt, with as little Wonder as a Land-creature ſhould, which who with Reaſon can imagine to have ever had at firſt ſo deep a Burial? Next, I ſay, the Mould, Soil, or Earth, wherein it lay, was altogether miry, like to that *cænum* (*ooſe*, ſome call it) on many Parts of the Sea-coaſt, both in *England* and abroad. But how poſſibly (will it be ſaid) a Sea-creature, when found at ſo remote a Diſtance from the Sea? For Solution (it may be) of this, and the like incidental Doubts, and removing all Rubs out of the Way of this Conjecture; I ſhall conſider the four following Queries:

1. Whether the Situation and Condition, Face and Figure, of the Place, may poſſibly admit of the Sea's once inſinuating itſelf thither?

2. Whether (that Poſſibility being granted, or evinced) the Sea did ever actually inſinuate itſelf ſo far as to this Place, and when?

3. How in Probability, and when, this Valley or Level, being once Sea-land, ſhould come to be ſo quite deſerted and forſaken of the Sea, as it is at this Day; the Sea not approaching by ſo many, a dozen Miles, or more?

4. By what Means the Sea, once having its Play there, this Creature comes to lodge, and be found ſo deep in the Ground, and under ſuch a ſhelving Bank?

1. As for the firſt (the Place's Capacity and Aptitude for the Sea's Influx or Inſinuation) ſuch as know the Situation, withal, cannot but know, and muſt agree it to be ſo. As for Strangers, and ſuch as are unacquainted with the Place, they are to be informed, that the Place (the *locus loci*) we are upon, is a Part of that wide, fair, and fruitful Level, or Valley, extending itſelf not leſs than twenty Miles in Length, between a continued Series and Range of Hills, Downs, or high Grounds, lying at a pretty Diſtance each from other all the Way; beginning at the *Eaſt Kentiſh* Shore, and ſtretching itſelf Weſtward by *Sandwich*, *Fordwich*, *Canterbury*, *Chartham*, *Chilham*, *Godmerſham*, *Wye*, *Aſhford*, ſometimes in a direct, ſometimes in a winding Courſe, as far at length, as to that famous ſpacious Level of *Romney-marſh*; and it is waſh'd and water'd all along, at leaſt from about *Aſhford*, by a ſweet and pleaſant River running through the midſt of it, as far as to *Sandwich*, and there by the Creek, or Haven, emptying itſelf into the Sea: Nothing at all of Obſtruction, by the Interpoſition of Hills, or high Grounds, hindering or controlling the Sea's free Play and Paſſage for ſo many Miles together. The Place then, with the Parts, the Tract above and below it, from the Condition or Conſtitution of it, is plainly not unapt or uncapable of the Sea's Inſinuation and Influence.

If any ſhall object, *Canterbury*'s being in the Way, as an Obſtruction or Bar; they are eaſily enough anſwer'd. For although that City ſeems (and indeed is at this Day) for the moſt part ſomewhat elevated above the Pitch of the reſt of the Valley or Level we are upon; yet not ſo much as to defend itſelf many times from Floods and Overflowings, in the lower, and moſt depreſſed Parts of it, even by the Springs it ſtands upon; towards the helping whereof, by the Care and Providence of former Ages, it is very certain, and by digging Wells, Vaults, Cellars, and the like, daily experimented, that the moſt Part of the City, not excepting the very Heart and Center of it, is made and raiſed Ground: The Tokens of Foundations upon Foundations, to a very conſiderable Depth, daily appearing, and the Ground (as at *Amſterdam*, *Venice*, and elſewhere) for ſupporting Superſtructures, in ſeveral Places often ſtuck and ſtuffed with Piles of Wood, or long Poles and Stakes, forced into the Ground, as Wells and Cellar-diggers have informed me. And, as if, where now the Bull-ſtake Market-place is kept, the River had ſometime had its Courſe or Current, Pits, and other like Tanner's Utenſils, have, not many Years ſince, been met withal in digging for Cellars thereabouts. To this let me add, that my next Neighbour in *Caſtle-ſtreet*, within theſe thirty Years ſinking a Cellar, did a good Depth (*five or ſix Feet deep*) light upon, and was put to ſome Stop and Stand in his Work by, a ſtrong and well-couched arched Piece of *Roman* Tile or Brick, which he was fain to take, or break aſunder, and remove, before he could proceed. However, then *Canterbury* may now ſeem to ſtand in the *Æſtuary*'s Way, yet Time was, when in Probability it did not; when, I mean, the Place, the Soil, which now the City occupies, as the reſt of the whole Valley both above and below it, was of too low a Pitch to be an Obſtacle to it.

As to the ſecond Enquiry, (whether probably the Sea did ever actually inſinuate itſelf ſo far as to this Place, and when) the Anſwer is not ſo eaſy: Record of it, we have none. The beſt and eldeſt Account we have now of the Condition, Site, and Conſtitution, of theſe our Eaſtern Parts and Tract, we owe to *Julius Cæſar*, and the *Romans* after him; from whom we have not the leaſt Hint of any ſuch Thing, but rather the contrary; both the Sea-coaſt and Inland Parts, by his and their Relation, bearing in a manner one and the ſame Face and Figure then, as now. However, that the Level we are upon, was ſometime an *Æſtuary*, or Arm of the Sea, ſeveral *Criteria*, or Tokens are not wanting: For Example, beſides what may be argued and inferr'd from this Parcel of ſtrange Teeth and Bones now under Conſideration; much (as I conceive) there is of Probability for it, reſulting from our River's Name of *Stoure* more anciently, not ſeldom both called and written *Æſtur*, *Æſture*, &c. which I doubt not to proceed and come from the Latin *Æſtuarium*, and in proceſs of Time to have been corrupted and contracted into *Sture* and *Stoure*; giving Name in part to *Stourmouth*, a Place about

ut ſix Miles Eaſtward from *Canterbury*; ſo called from the River's
mboguing there into the Sea or Salt-water flowing up thither, as alſo
ing Name to the Manor of the Archbiſhop's, at this Day, and for
e Ages paſt called *Weſtgate-Court*, at *Canterbury*; but more ancient-
as in the Conqueror's Time, (witneſs *Domeſday* Book) called the
nor of *Eſture* and *Eſtureſate*, from its Situation by the *Sture* or *Stoure*.
m which Occaſion, doubtleſs, the late Lord *Finch*'s Seat in ——
ut five or ſix Miles nearer to the Spring-Head, at this Day vulgarly
called *Eaſt-Steward*, is of old ſometimes called *Eſture*, ſometime *Et*
e. From *Saxon* Monuments and Records I could eaſily trace the
me up to a very high Date, by many Examples.

But to proceed to other *Criteria*; as by the Teeth and Bones now
der Conſideration, we have an Inſtance on that Side of the Valley for
Probability of the Sea's *quondam* Occupation of it; ſo I ſhall give
e another no leſs remarkable from the other, or oppoſite ſide of it.
credible Relation, then, at a Place called *Webſtere*, an obſcure Vil-
e about three Miles from *Canterbury*, Eaſtward, lying under the Brow
the Hill ſtretching out by *Upſtreete*, as far as to the Weſt-end of *Sarr-*
ll, by which you make your Entrance into *Thanet*, upon the like
caſion to that here at *Chartham*, (the digging or ſinking of a Well)
a very great Depth, ſtore of Oyſters and other-like Shells, together
h an Iron Anchor, firm and unimpaired, were found and turned up
our Time. The like I have been told of an Anchor in our Days,
ged up at *Broomedowne*, on the ſame ſide of the Level, ſomewhat
ve *Canterbury*, Weſtward.

As to the third Query, how in Probability, and when this Valley or
vel, being once Sea-land, ſhould come to be ſo quite deſerted, and
ſaken of the Sea, as it is at this Day, the Sea not approaching it by ſo
ny, a dozen Miles, or more? In Anſwer whereof, I muſt needs ſay
l grant, that in caſe this Level were once Sea, an *Æſtuary* I mean,
Arm of it; ſo very long it was ago, as we may not reaſonably think,
t *Canterbury* (whether as a City, or never ſo mean a *Pagus*, or Village)
then in *rerum natura*, or a Place inhabited; which haply it may
e been, if not as long as *Julius Cæſar*'s Days, yet undoubtedly not
g after. For an Account we have of it (as of ſome other Places in
t) in the *Romans* Time, from *Ptolomy*, *Antoninus*'s *Itinerary*, and elſe-
re. Now elder Records, either of *Kent*, or of *Britain*, that we
y confide in as authentic, we have none, that I know of, before the
mans Time. We muſt either, therefore, throw off all further Inqui-
or elſe caſt about for Information as we can. Such as are for this
er, will tell you, that the World is very aged, many thouſand Years
, and that many and manifold are the Alterations which Time hath
le in ſeveral Parts and Quarters of the World; to the Notice and
covery whereof no written Record, or unwritten Tradition at this
, can reach or direct us: Tradition itſelf (longer liv'd many times
any written Evidence) failing us for Age. Of ſuch a Nature they

conceive may this of the *Æſtuary* be, ſo very ancient, as Time hath quite worn out the Memory of it; and that the Reaſon of the Sea's Receſs here, with an abſolute Valediction to the Place of its wonted Reſort, was its breaking, burſting, and cleaving aſunder, that *Iſthmus*, or Neck of Land, between *Gaul* and *Britain*, rendering the latter of the ſame Continent with the former: Such Things ('tis certain) have happen'd elſewhere. Thus (ſays *Seneca)* hath the Sea rent *Spain* from the Continent of *Africk*. Thus (as he adds) by *Deucalion*'s Flood was *Sicily* cut from *Italy*. More Inſtances of this Kind may be found in Mr. *Cambden*'s *Cantium*, and elſewhere. And although there be no certain Evidence of ſuch an Accident here, from ancient Hiſtorians or Geographers, yet is the Thing ſo ſtrongly and rationally argued, by him eſpecially, as by *Verſtegan* alſo, *Twine*, and others before him; and the Conjecture back'd with ſuch Plenty of probable *Criteria*, by the former, that I cannot but be of that Opinion; eſpecially, when to the Plenty of Arguments muſter'd up by Mr. *Cambden*, I ſhall have contributed this one, by him and the reſt omitted; which is, that by a received conſtant Tradition, *Romney-Marſh*, that large and ſpacious Level, containing (ſaith Mr. *Cambden*) fourteen Miles in Length, and eight in Breadth, was ſometime Sea-Land, lying wholly under Salt-water. And if I may gueſs at the Time and Occaſion of both that, and our *Canterbury* Level's Recovery from the Sea, I ſhall be apt to pitch upon that of the Sea's breaking through, and in Time working and waſhing away that *Iſthmus* between us and *France*. And then, whereas beforetime *Romney* Level (which had and hath its *Stoures* too, or *Æſtuaria* as well as ours) and this other not improbably (no high Lands, as we ſee, interpoſing or impeding their Conjunction) were but one and the ſame Level, and lay under the Sea; now both the one and the other (the Sea having ſo much more Play and Elbow-room, than formerly, by cleaving aſunder the *Iſthmus)* were reſcued from it, and of an *Æſtuary* became ſuch a rich and noble Valley or Level, as is ſecond to none in *England*.

And if from hence any one ſhall take an Hint, to conſider of the *Netherlands* or *Low Countries*, and enquire whether thoſe in whole, or in part, may not have ariſen out of, and conjecturally aſſigned for our *Kentiſh* Lowlands, I ſhould not at all wonder at it.

As to the fourth Query, by what Means the Sea once having its Play there (at *Chartham)* this Creature comes to lie and be found ſo deep in the Ground, and under ſuch a ſhelving Bank? My Anſwer is, That ſuppoſing this with the reſt of the Level or Valley once occupied by the Sea, or Salt-water; that being a Creature which by Fluxes and Refluxes always is in Motion, and thereby in Time beating upon, and working itſelf into the Bank, or riſing Ground there, might at length ſo far undermine, eat into, and looſen it, as to fetch down ſo much Mould or Earth upon, or over the Place, as to lodge the Creature at ſo great a Depth. Or elſe perhaps, the continual Agitation of the Water might in Time force, drive up, and caſt over it that great Quantity

tity of Ooſe, Earth, and other Matter, under which it lay. By the way, it is obſerved, that the Nature of the Soil here and there is ſuch, ſo looſe, ſupple, rotten and ſandy, that meerly of itſelf, it is apt to ſink, and fall in; as was lately experienced by a Saw-pit digg'd hard by, which after a little Time, by the Earth's giving way on each Side of it, fell in, and fill'd up itſelf.

Fig. 26, 27. *Repreſent two of the* Teeth *above mention'd.* Fig. 26, 27.

2.] Mr. *Somner* is of Opinion, (with Mr. *Cambden*, and other Antiquaries) That is highly probable (if not abſolutely certain) that *France* and *England* (or *Gaul* and *Britain*) were anciently joined by an *Iſthmus*, or Neck of Land, where now is the narrow Paſſage between *Dover* and *Calais*: Which, many Ages ſince (beyond the reach of any Hiſtory now extant) was (by the Seas violently beating upon it on both Sides) worn away, or broken through. Whereby, what was once an *Iſthmus*, is now become a *Fretum* or narrow Sea.

—on the ſame, by Dr. J. Wallis. n. 275. p. 967.

Mr. *Cambden* is his *Britannia* (in that Chapter where he treats of *Kent*, or *Cantium*) gives us many cogent Arguments, which, if taken all together, ſeem to me a convincing Evidence, that there had once been ſuch a Conjunction; but not for many Ages now paſt.

To which I may add one more (of which Mr. *Cambden* takes no notice in this Place) from the *Unity of Language* between the ancient *Gauls* and *Britons*; and from the great Intercourſe between thoſe in *Gaul*, and the *Druides* in *Britain* (of which ancient Writers take notice:) which is not likely to have been, if there had not been an eaſy Communication between the one and the other. Which, though it be not a *Phyſical* Argument (as are thoſe of Mr. *Cambden*) is a good *Moral* Inducement, in Confirmation of them.

To thoſe Arguments of Mr. *Cambden*, Mr. *Somner* adds another, *a Parcel of ſtrange and monſtrous Teeth and Bones*, which (in the Month of *September* 1688.) upon digging a Well in the Pariſh of *Chartham* (about three Miles Southward from *Canterbury*) in the Land of Mr. *John Somner*, were found at the Depth of *ſeventeen Feet under Ground.* Which *Bones* and *Teeth* (from the Figure and Greatneſs of them, and from the Condition of the Earth wherein they were found) he judgeth to have been the Remainders of ſome *Hippopotamus*, or other large *Marine* Animal, which (many Ages ſince) had periſhed there; which hath ſince been covered with this Depth of Earth.

This *Chartham* he obſerves to lie about the middle of a large rich Valley, for about twenty Miles or more in Length, and of a conſiderable Breadth; having on each Side of it, at a conſiderable Diſtance, a long Tract of Hills, or high Grounds. Through which Valley, there now runs the River *Sture*, *Stoure*, or *Eſture*, for twenty Miles or more, by *Aſhford*, *Wye*, *Godmerſham*, *Chilham*, *Chartham*, *Canterbury*, *Fordwich*, and ſo to *Sandwich*, where it diſcharges itſelf into the Sea.

This long and large Vale, (from the Situation of the Place, the Nature of the Soil, and the Remains of this Marine Animal, lodged here at ſo great a Depth under Ground) he judgeth to have been (in former Ages) an *Æſtuarium*, or Arm of the Sea, into which the Sea, (being ſtopped by the *Iſthmus*, which then joined *France* and *England*, from the Courſe which now it takes) did diſcharge itſelf; which, in Proceſs of Time, being filled up, (partly by the Earth, Sand, Ooſe or other Matter brought in by the Sea, and lodged there, partly by the Earth waſhed down, or falling upon it from the Hills on both Sides) is reduced to the State we now ſee.

Let us then conſider, what muſt have been, if this Hypotheſis be true; and how it agrees with what we ſee.

Firſt, if ſuch an *Iſthmus* had once been, where now is the Paſs between *Dover* and *Calais*, the great Seas on both Sides muſt continually beat upon it with a fierce impetuous Tide, twice in four and twenty Hours. The Northern Sea between us and *Holland* (called *Oceanus Germanicus*) on the Eaſtern Side; and the Weſtern Sea between Us and *France* (called *Oceanus Britannicus*) on the Weſtern Side. Which (in Proceſs of Time) may well be ſuppoſed likely enough to wear away, or break through a narrow *Iſthmus*.

The Weſtern Tide coming in fiercely between Us and *France*, fretting on the Coaſt on both Sides, muſt needs be ſuppoſed to bring with it a great deal of Earth, Sand or Mud. But, being ſtopped in its Current by this *Iſthmus*, did not depoſit it (as might be thought) on the Side of it, (which might ſtrengthen it) but found an Opportunity of diſcharging itſelf on the ſpacious Level of *Romney-Marſh*; (which, as *Cambden* tells us, is *fourteen Miles in length, and eight in breadth*) fretting that *Iſthmus* as it comes along; and then (at ſtanding Water, about the Tide's Receſs) letting it fall on that Level, and lodging it there: But then again, fretting that *Iſthmus*, and the Coaſt all along, as the Tide returns, with a like Force as it came in. Which gives us a fair Account, both how that *Iſthmus* might be waſhed away, and how that Level might be raiſed to that Height it now is. For no Man can doubt (who doth well know the Situation of the Place, and the Nature of the Soil) but that all that Level had heretofore been Sea. And, even at this Day, it lies ſo much lower than the Surface of the Sea at High-Water, that it would (much of it) be overflowed every Tide, if not defended (at a vaſt Charge) by *Dim-church* Wall, for many Miles together.

Whether it had a like Opportunity of ſuch an Indraught (and in what Proportion) on the *French* Coaſt, I cannot tell. But, that this is the Condition of *Romney-Marſh*, no Man doubts.

The *Northern* Sea (between us and *Holland*) muſt, in like Manner, have beat on the Eaſt Side of that *Iſthmus* with a like impetuous Tide, twice in four and twenty Hours. But, being there ſtopped in its Courſe, would have the like Opportunity of diſcharging itſelf on the Coaſt of

Holland, (as the Weſtern Sea on *Romney-Marſh*.) Whence it is, that *Holland* and *Zealand*, which (by the Conſent of all) is judged to have been once Sea, is now raiſed thirty or forty Feet higher than it had once been.

And the ſame *Northern* Sea, which (on this Account) hath ſo large an Inlet (Eaſtward) on the Coaſt of *Holland*; would (Weſtward) inſinuate itſelf likewiſe on the *Engliſh* Coaſt, where-ever it might find low Grounds. Which is the Caſe of this Valley, where now runs the River *Sture*, *Stoure* or *Eſture* (which Name it is ſuppoſed to have taken from the Corruption of *Æſtuarium*) for more than twenty Miles; (and nothing appears why we ſhould not think it had ſo done;) entering at the low Grounds near *Sandwich* (cloſe by that *Iſthmus*) and running up that Level (by *Canterbury*, *Chartham*, *Chilham*, and ſo forth) as far as *Aſhford*, or farther, which Valley had once been much deeper than now it is. For, it ſeems, that even at *Chartham* (which is now twelve Miles from the Sea) the Ground is raiſed at leaſt ſeventeen Feet; and the Soil, at that Depth, found to be of a like Condition, as where the Sea is known to have been; and nearer to the Sea, it may well be preſumed to have been yet deeper. Which is confirmed by the Reliques of this Marine Animal there found; and by Anchors, and Shells of Fiſhes, found elſewhere in the Borders of this Valley, at a great Depth under Ground.

Now, that the Sea may thus raiſe the Ground on ſuch In-draughts, by Sand, Earth and Mud, brought in and lodged there at every Tide, is not at all unlikely: For we ſee the ſame at this Day. Particularly, in the Iſle of *Oxney* (near adjoining to *Romney-Marſh*) there was a low Level, oft in Danger of being overflowed by the River *Rother*: But, ſomewhat more than threeſcore Years ago, the Sea being let in, hath raiſed that Level very conſiderably; by bringing in, and lodging there a conſiderable deal of Earth and Mud every Tide: But withal, it hath ſo fretted the Channel, by which it enters and goes out again, that the Channel by *Rye*, which (within my Memory) was ſo ſhallow near what was call'd *Kent*-Bridge, that Men were wont to ride through it; but now (by the Tide's entering and returning) that Bridge is long ſince ſwallowed up, and the Channel become ſo broad and deep, that a Veſſel of good Burden might ride there at Anchor. A fit Reſemblance of the Sea's fretting this *Iſthmus*, and filling up the *Æſtuaries* on both Sides of it.

The like, in good Meaſure, is to be ſeen at (what they call) the *Dogger Sands*, which is a Bank of Sands lying (obliquely) from about the Coaſt of *Norfolk* toward the Coaſt of *Zealand*, or North-part of *Holland*, which is the Place where the Northern and Weſtern Tides (ſince the Rupture of the *Iſthmus*) do now meet; and do there (at ſtill Water, for about half an Hour or more, or at the turning of the Tide) depoſit the Mud and Sand, which (by their rapid Motion) is both Ways brought thither. Which is ſuppoſed to be the true Cauſe of that ſandy Bank. Whether this in Tract of Time may there form a new *Iſthmus*, (if the World laſt long enough) I cannot ſay, but I am apt to think that the former *Iſthmus*, if the Tides had ſtopped there, and had not found thoſe In-draughts, on which to lodge what it waſhed from thence, might have continued, and been more ſtrengthened, by what (upon the Return of the Tide) would daily be lodged there.

And upon this Account (I think) it is, that the *Iſthmus* at *Corinth*, though beat upon by two Seas (which gave it the Name of *Bimaris Corinthus*) is not thereby deſtroyed: becauſe there are not ſuch Tides to waſh it away, nor ſuch In-draughts, on which to lodge what ſhould be waſhed from thence.

But the Caſe is much otherwiſe with this *Iſthmus* of ours; where are all Things to countenance this Hypotheſis. The ſteep Cliffs at *Dover*, and thoſe at *Calais*, anſwering directly the one to the other; and appearing to View, as if that between them had been violently torn away. And the Sea between them (even at this Day) being much ſhallower at that Place than on either Side of it (as *Cambden* doth well obſerve) which are ſtrong Preſumptions, that there had been formerly ſuch a Conjunction.

The greateſt Doubt in this Caſe is, that there is no Hiſtory extant, which takes notice of ſuch an *Iſthmus*, or ſuch a *Rupture*, in this Place, which being a Thing remarkable, might have been thought worthy to be reported.

Which yet need not be thought very ſtrange, conſidering that we have no particular Account of the *Britiſh* Coaſt (which might determine this Queſtion) older than the *Romans* Acceſs hither with *Julius Cæſar*: Whereas this might happen'd many Hundred of Years before that Time, when though the Iſland might be known, yet not the particular Coaſtings of it to the *Greeks* or *Latins*.

But I have this farther to ſay; *Plato* tells us a Story (as of a Thing which happened ſome Ages before his Time, and which at that Time was in a manner generally forgotten) of an Iſland ſomewhere in the *Atlantick* Ocean, which by a Deluge and Earthquake (in the Space of a Night and a Day) was deſtroyed and ſwallowed up by the Sea; whereby that Sea (formerly navigable) was for ſome Time become unnavigable or unſafe, by Reaſon of the Mud and Reliques of that abſorbed Iſland. The Words of *Plato* (as tranſlated in *Henry Stephens*'s Edition, p. 25.) runs thus; *Poſt autem, quum diluviorum & terræ motuum intemperies extitiſſet, unius noctis & diei ſpatio, omne illud bellicoſorum hominum genus in terram abſorptum fuit, illaque etiam Atlantica Inſula* (Ἀτλαντὶς νῆσος) *maris fluctibus plane obvoluta diſparuit, unde & illud mare trajectu difficile eſt, quum lutum adhuc copioſum Inſulæ iſtius remanſerit.*

Which ſeems to me very applicable to the Rupture of this *Iſthmus*: Whereby this Iſland was not indeed wholly deſtroyed, but was broken off from the Continent, to which it was before united. And, upon ſuch an Accident, the Sea muſt needs be diſturbed, and put out of its Courſe, and render'd unſafe for Paſſage, before it came again to be ſettled. For though the firſt Breach might be made in the Space of one Night and Day, we cannot ſuppoſe the whole Bulk of it, when once broken, was preſently carried ſmooth away; but firſt the Top or upper Part of it (in a Day and Night's Time) and afterwards the lower Parts of it by Degrees. Which would render that Sea, if not quite unpaſſable, at leaſt troubleſome and unſafe.

And if in ſome Circumſtance this Narration chance to differ from the Matter of Fact, as calling the *Rupture* of this *Iſthmus* the *Subverſion* of an *Iſland*, this muſt be allowed in the Narrative of an old Tradition from Hand to Hand: For as ſuch it is there brought in.

For *Plato* doth there introduce *Critias* (then an ancient Man) telling a Story, which (when a Boy of ten Years old) he had heard from his Grandfather (who was ninety Years of Age) of what *Solon* (long ſince dead) had told him; namely, that an *Ægyptian* Prieſt had (long before) told *Solon*, that it did appear from ſome old *Ægyptian* Records (of which the *Greeks* had no Knowledge) that ſuch a Thing had happen'd in an Age ſo long before, as in compariſon of which *the Greeks were but as Children.* And all this Tradition (through ſo many Hands, and at ſuch great Intervals of Time) is, at every Step, reported from the Relator's preſent Memory. And 'tis very poſſible, that ſome one or other of theſe Relators might ſo far miſtake, or miſremember, as to call that a *Diſſolution* or *Diſappearance* of an Iſland (*ἠφανίσθη*) which was but a *Tearing it from the Continent.*

It ſerves, however, to the preſent Purpoſe, if at leaſt ſo much of the Story be true, *That long before* Plato's *Time, there had been ſome ſuch Diſſolution or Rapture of an Iſle or Iſthmus, ſomewhere in the* Atlantick *Ocean,* (that is, in the Northern Sea) *of which there were ſome Symptoms yet remaining in* Plato's *Time.* For, this being admitted, it is as applicable to the preſent Caſe (as to any we know) of which there are ſo many Symptoms yet remaining to this Day.

I know that *Rudbeck* in his *Atlantica*, Cap. 7. Sect. 8. pag. 293. doth endeavour (in Favour of his *Sueonia*) to put an allegorical Senſe upon this whole Paſſage.

But I ſee not why it may not be underſtood in a plain literal Senſe, as a true Matter of Fact, (though perhaps a little diſguiſed, as was wont to be the Faſhion in that Age in relating old Stories) and is very conſiſtent with all that *Rudbeck* cites out of *Plato*, in that whole ſeventh Chapter of his *Atlantica*.

For the Name of the *Atlantick Sea* (wherein this Iſland is ſaid to be) was not then (nor is now) confined to the Coaſt of *Sweden*, but extended as far as the *Britiſh* Iſland, and much farther. And when *Rudbeck* tells us out of *Plato*, that the whole *Atlantica* was as big as *Libya* and *Aſia* (which whether meant of *either of them* ſingly, as *Rudbeck* underſtands it, or of *both together*, as the Words ſeem to import,

port, *ἅμα Λιβύας καὶ Ἀσίας μείζων*, I will not contend; we cannot ſuppoſe it to be *Plato*'s Meaning, that this *whole Region* was ſwallowed up; but rather ſome ſmall Part of it, from whence perhaps the whole might take its Denomination. And though he tells us from another Writer, that it was *five Days Voyage* from the *Britiſh* Iſland, to (that part of) his *Atlantica*, where for *thirty Days together the Sun doth not ſet*; this hinders not, but that the *Britiſh* Iſlands may be part of the *Atlantick Region*, though ſo far diſtant from the utmoſt Northern Cape of it.

I know not whether I may yet venture farther: This Author tells us, that this *Æſtuary* (from *Sandwich* to *Aſhford*) might perhaps flow ſo much farther, as to meet with that *Æſtuary* on *Romney-marſh*, and (both being conjoin'd) become *one Level*.

There is, I think, about three or four Miles diſtance between *Aſhford* and the neareſt part of *Romney-marſh*: How the intermediate Lands be qualified, I do not well remember.

But if this be admitted, that the two *Æſtuaries* (that of *Stoure*, and that of *Romney-marſh*) in former Times may thus have met; this opens a new Scheme, of which before we were not aware. For then we muſt ſay, that the two Tides (that from the North and that from the Weſt) which now meet at the *Dogger Sands*, did then meet at the Confluence of theſe two *Æſtuaries*: And then (as was ſaid of the *Dogger Sands*) bringing, on both Sides, Earth, Mud, and Sand, to this Place, and lodging it there, might firſt form an *Iſthmus* there, and, by Degrees, fill up thoſe *Æſtuaries* on both Sides: In the mean while, waſhing away that *Iſthmus* between *Dover* and *Calais*, and opening a new Paſſage as now it is.

There be many other *Æſtuaries* in *England*, where the Sea now enters a great Way into the Land; and how far it might have entered farther in former Times, who can tell? As that Sea by *Briſtol* between *Wales* and *Cornwall*: That of the *Humber* between *Yorkſhire* and *Lincolnſhire*: And we may reaſonably think, that the *Waſhes* and the *Fens* in *Lincolnſhire*, may have heretofore been Sea, or overflowed by the Sea at high Tides: And that of the *Thames* (between *Kent* and *Eſſex*) which now flows (above *London* and *Brentford*) within a Mile of *Kingſton* (at Spring-Tides); it may perhaps ſeem too daring, to think it may formerly have flowed as far as *Oxford* (between *Shot-over* Hill and *Foxcomb* Hill) and ſo onward toward *Wallingford* (in the *Romans* Time called *Galena*); but there is this to countenance it, that (if I be not much miſinformed) there be frequently found (in our Stone-Quarries and Gravel-pits) about *Oxford*, Fiſh-ſhells, and even the Bodies of Fiſh petrified, at great Depths under Ground. And there have been (no doubt) and now are (in *England*) many other *Æſtuaries*, Creeks, or Arms of the Sea (entering a great Way within Land) ſome whereof may be in a Manner filled up, and become firm Land; others much narrower, ſhallower and ſhorter, than in former Times they have been. For it is the Nature of *Æſtuaries*, where the Tides flow in, to leave behind them, at their Return, much of Mud, Ooſe, or Sleech, as they call it, which doth in Time come to be firm Land.

—*on the* ſame, *by the* ſame, *ibid.* p. 978.

3.] At *Hythe* in *Kent* (which is one of the *Cinque Ports*) there was (in our Fathers Time) a convenient Harbour for ſmall Veſſels, which is now ſwarved up; ſeveral Attempts have been made to recover the Harbour, but with ſmall Succeſs. For when (with great Labour and Charge) they have (in ſome Meaſure) opened it, it hath ſoon been filled up again, by what the Sea caſts up. And whoever conſiders the vaſt Quantity of (what they call) *Beach*; that is, a vaſt Multitude of ſmall looſe Stones and Fiſh-ſhells, caſt up by the Sea at *Hythe*, *Lyd*, and elſewhere, on the Coaſt of *Romney-marſh*, (for divers Miles in Length and Breadth, and to a great Depth) will not think it ſtrange, that a *Creek* or *Æſtuary* ſhould come in Time to be filled up, and become firm Land. And in many Places of this *Beachy* Ground, where (within the Memory of Perſons now living) nothing was to be ſeen, but ſuch looſe Stones and Shells (to a great Depth) it comes (by Degrees) to be covered with Earth, and becomes Paſture Ground.

On the contrary, that what was formerly Firm-land, may be ſo deſtroyed or waſhed away, as to become Sea, is evident from (what they call) the *Goodwin-Sands*, on the Coaſt of *Kent*, which is ſaid to have been the Lands of Earl *Goodwin*, but loſt by an Inundation about the Time that *Tenterden* Steeple was built, (which gave Occaſion to that Ironical Proverb of Things Cotemporary, that *Tenterden Steeple was the Cauſe of* Goodwin *Sands.*) The Occaſion of ſuch different Effects, depending on the different Situation of the Shores, and the ſetting of the Tides; ſo as to waſh off from one Place what it lodgeth on another.

And many ſuch Alterations (no doubt) have been of the Face of the Earth, all the World over, of which we have no particular Hiſtories. For the World was of great Age, before the writing of any Hiſtories (except the Bible) now extant.

And who knows, but that in former Ages, even amidſt the *Alps*, there may have been large *Lakes*, which, in proceſs of Time, (by Earthquakes or other Accidents) may have been drain'd of their Water, and become fruitful Valleys: Of which it is ſaid, divers Symptoms have been diſcover'd, even amidſt the *Alps*, in later Ages.

And ſomething of the like Nature hath happen'd within ſome few Years laſt paſt, in *Jamaica*, in *Sicily*, and other Places.

——*on the* ſame, *by the* ſame. n. 276. p. 1030.

4.] Since I wrote laſt on the Subject of the *Iſthmus*, &c. I find Mr. *Luffkin* † has informed us of divers Bones of an extraordinary Bigneſs, found lately in a Gravel Pit, not far from *Harwich* in *Eſſex* (much like thoſe found at *Chartham* in *Kent*,) at a great Depth under Ground, which Bones he thinks rather to have been the Bones of an Elephant, than of an *Hippopotamos*, or other Marine Animal.

† *Vid.* infra, S. X.

But which ever it is, it will equally prove thoſe Valleys to have been much deeper in former Times, than now.

I obſerve, that the River in *Eſſex*, and that in *Kent*, near which the Bones were found, are both of them named the *Stowr*; which, whether it be a Corruption of the *Latin Æſtuarium* (as Mr. *Somner* conjectures) or of the *Britiſh ys-dwr*, (that is, *the Water*) I will not diſpute.

And that the Bones were found (in both Places) much at the *ſame Depth*, (about 16 or 17 Feet under the Surface of the Earth) which therefore may (probably) have been lodged (in both Places) much about the ſame Time: And perhaps, when the Emperor *Claudius* brought his *Elephants* into *Kent* and *Eſſex*; as Mr. *Luffkin* intimates out of *Dion Caſſius*.

I obſerve alſo, that thoſe petrified Bones, in both Places, were found in *gravelly Grounds*, (as are thoſe petrified Shells, and Bodies of Fiſhes, in Gravel Pits and Stone-Quarries near *Oxford*). How far the Steams, Fumes, or Fluors of the Earth, which contribute to the Formation of Stone or Gravel, may conduce to the petrifying of theſe Bones, Shells, or other Bodies; I leave to the Conſideration of the Naturaliſts.

And whether the Impregnation of ſuch *Steams*, may not *Swell* ſuch petrified Bodies, to a larger Proportion than before they had. Like as we obſerve Wood (and other like Materials) in a moiſt Air to Swell; by the Diſtention of their Pores, upon the Intromiſſion of moiſt Particles. For I take all Petrifications to be made, either by *Incruſtation* or *Intromiſſion* of ſtony Particles.

And I well remember, that (many Years ago) at *Moldaſh* in *Kent*, (not far from *Feverſham*) on ſome high Grounds, and very ſtony, (which uſed to be ſometimes Paſture, and ſometimes plow'd) I have obſerved divers *Oyſter-ſhells* (petrified, or partly ſo) much larger and thicker than the ordinary Proportion of Oyſters in thoſe Parts, and very weighty; which Oyſter-Shells might have been purpoſely thrown there long before, as being reputed a good Manure for Land; and might have been there impregnated with like *Halitus*, *Effluvia*, as are the numerous Stones on thoſe Lands.

I have known the Inhabitants, heretofore, have uſed to cauſe the Stones, in thoſe Lands (becauſe they are very numerous) to be gather'd up, and carried off the Lands by Cart-loads, to make more Room for the Graſs to grow. But of later Years, they forbear (I have been told) ſo to do, as thinking the Warmth (or ſomewhat equivalent) of thoſe Stones, is rather an Help, than Hindrance of the Earth's Fertility.

But (to return to what I was ſpeaking of) I ſee not why we may not think the *Stowr* in *Eſſex*, and the *Stowr* in *Kent*, to have been (both of them) *Æſtuaries* of the *Northern Tyde*; before the Rupture of that *Iſthmus* between *Dover* and *Calais*: (And the like of the River near *Malden*, and other ſmall Creeks on the Coaſt.) Though not ſo great as thoſe of *Humber* and the *Thames*: which were then *Æſtuaries* of the ſame Sea; as are many others on the Coaſt of *Scotland*.

I ſay, *before that Rupture*; For, ſince that Rupture, the Caſe (as to the *Thames*) is ſomewhat altered. For the Weſtern Tide (between us and *France*) which was then ſtopped at this *Iſthmus*, doth now flow on (through that *Fretum*) beyond the Mouth of the *Thames*, as high as the *Dogger-ſands*; which doth therefore ſupply the *Æſtuary* of the *Thames*, which was formerly furniſhed from the Northern Sea.

And theſe ſmaller *Æſtuaries* might ſooner be ſwarved up by what every Tide lodgeth there, while thoſe greater *Æſtuaries* are but ſhortned, and become narrower, than they had formerly been.

And as to the *Thames* in particular; it ſeems very evident, if we conſider their Situation, and the Nature of their Soil, that much of the Low Grounds (in *Kent* and *Eſſex*) on both Sides of the Mouth of the *Thames* (adjacent to the Sea) had formerly been Sea, (as well as that of *Romney-marſh*.) And when the Mouth of the *Thames* was ſo much wider, no doubt but it flowed much farther than now it doth. And how far, who can tell?

It may perhaps be objected, that the ſmall Rivers now remaining, in the Bottom of theſe Valleys, which may have been ſuppoſed (in former Times) to have been *Æſtuaries*, do now run more wriggling (with more Turnings and Windings) than do theſe Valleys. But this need not at all ſeem ſtrange, when as we may daily ſee the ſame, in the Bottom of a muddy Ditch (or Water-courſe) when the Water is almoſt drained off, the Mud yet remaining ſoft: the little Water, yet remaining, will work out of itſelf (amidſt the Mud) a wriggling Paſſage (according as the Mud will more or leſs give way) much more crooked, than was ſuch Ditch when full of Water, and the like muſt needs happen in the gradual Draining of ſuch *Æſtuaries*, according as the ſoft Earth will permit. Which Crookedneſs will continue, when the Banks on both Sides do (by Degrees) grow firmer.

As to what I ſaid concerning the Iſle of *Oxney*; A low Level in that Iſle, which had for divers Years lain under Water, is now raiſed by intromitting the Tide, to a conſiderable Height above what it had formerly been; and the Channel from thence to *Rye*, is (by the Tide's paſſing in and out) become much wider and deeper than heretofore. Both which are evident, and not to be denied.

If we look in the more ancient Maps of *Kent* (older than the Year 1640) we will find, that what we call the *Iſle of Oxney*, was then but a *Peninſula*; being (by a ſmall *Iſthmus* or Neck of Land at the North-Eaſt Corner of it) continued to the reſt of the Country: And the Tide from *Rye* to that Place (which now flows ſtraight onward on the North Side of the Iſle) was there ſtopped by that *Iſthmus*, and did wheel about on the South Side of it: Or rather, the River *Rother* did (from the North Side of the Iſland) wheel about by the South Side (to that Eaſtern Corner) and thence (by the Channel) to *Rye*.

While Things were in this ſtate; divers Mooriſh or Marſh-lands, adjoining to the River *Rother*, were oft in Danger (upon great Rains) to be drowned. But ſo it once happened (by what Accident I know not) that this drowned Land had unexpectedly (in a Night's Time, or little more) diſcharged itſelf on another Level, ſomewhat lower than itſelf.

Upon which Indication, it was thought adviſeable (by cutting that *Iſthmus*) to allow thoſe Waters on the North Side of the Iſland a ſtraighter Paſſage towards *Rye*; and to let thoſe lower Grounds for ſome Time to lye under Water (paying the Rent of them) till ſuch Time as (by intromitting the Tide) they might be ſomewhat heightned, and then timely recover'd. In Order to which, Commiſſioners of Sewers have ever ſince from Time to Time been iſſued out for that Purpoſe; and the Work in a good Meaſure effected, though not finiſh'd.

An Account of Large Teeth *dug up in* Ireland, *by Mr.* F. Neville. n. 346. p. 367.

IX. 1.] Four large Teeth were lately found in the North of *Ireland*, about eight Miles from *Belturbet*, at a Place call'd *Magbery*, in Part of the Biſhop of *Killmore*'s Lands, ſinking the Foundation for a Mill near the Side of a ſmall Brook, that parts the Counties of *Cavan* and *Monaghan*.

Two of them are of a larger and two of a ſmaller Sort; the largeſt is the fartheſt Tooth in the under Jaw, the other is like it, and belongs to the oppoſite Side; the leſſer Tooth I take to be the third or fourth Tooth from it, and has its fellow: Theſe are all that were found, and one of them in a Piece of the Jaw-bone, which fell to Dirt as ſoon as taken out of the Earth; there was Part of the Scull found alſo of a very large Size and Thickneſs, but as ſoon as expoſed to the Air, that mouldered away as the Jaw had done.

The Account I had, led me laſt Week to the Place where I was reſolved to make the niceſt Search I could; but the Water-wall of the Mill being built, and the Ground all incumbered with the Earth, that was thrown up, I could have little Opportunity of doing any Thing but to enquire of the Workmen the Manner of finding the Teeth, and where and how they lay. There were ſome few Pieces of Bones found, but none entire, yet by thoſe Bits that were found, one might gueſs that they were Parts of thoſe that were of a larger Size.

The Place where this Monſter lay was thus prepared; which makes me believe it had been buried, or that it had laid there ſince the Deluge. It was about four Feet under Ground, with a little Riſing above the Superficies of the Earth, which was a Plain under the Foot of a Hill, and about 30 Yards from the Brook or thereabout. The Bed whereon it lay, had been laid with Fern, with that Sort of Ruſhes here called

Sprits, and with Buſhes intermixed. Under this was a ſtiff blue Clay, on which the Teeth and Bones were found: Above this was firſt a Mixture of yellow Clay and Sand, much of the ſame Colour; under that a fine white ſandy Clay, which was next to the Bed: The Bed was for the moſt Part a Foot thick, and in ſome Places thicker, with a Moiſture clear through it; it lay ſad and cloſe, and cut much like Turf, and would divide into Flakes, thicker or thinner as you would; and in every Layer the Seed of the Ruſhes was as freſh, as if new pulled, ſo that it was in the Height of Seed-time, that thoſe Bones were laid there. The Branches of the Fern, in every Lay as we opened them, were very diſtinguiſhable, as were the Seeds of the Ruſhes and the Tops of Boughs. The whole Matter ſmelt very ſour, as it was dug, and tracing it I found it 34 Feet long, and about 20 or 22 Feet broad.

It will be well worth Conſideration, what ſort of a Creature this might be, whether Human or Animal: if Human, there was ſome Reaſon for the Interment, and for that Preparation of the Bed it was laid on; if Animal, it was not worth the Trouble; if Human, it muſt be larger than any Giant we read of; if Animal, it could be no other than an Elephant, and we do not find, that thoſe Creatures were ever the Product of this Climate. And conſidering, how long this muſt have laid here, I do not believe the Inhabitants then had any Curioſity or Conveniency to bring ſuch into this Kingdom; for I ſuppoſe the beſt of their Ships could not carry one. Then if an Elephant, or ſome other Beaſt which muſt have Proportion to the Teeth, it muſt have laid there ever ſince the Flood; and if ſo, then the Bed, on which it lay, muſt be of its own making: Whence it will follow, that the Flood coming on him, while he lay in his Den, he was there drown'd, and covered with Slime or Mud, which ſince is turn'd into the Subſtance of the Earth before-mention'd. There were alſo a great many Nut-ſhells found about the Bed, perhaps thoſe might have been on the Buſhes, which compoſed Part of the Bed.

The two large Teeth are of equal Weight, two Pound three Quarters each: The two little Teeth are ſix Ounces each; but there are ſome of them waſted, and ſome of the Holders that go into the Jaw broken off.

—Remarks *on them by Dr.* T. Molyneux. *ibid*, p. 370.

2.] The *Four Teeth*, with ſome of the Fragments of the Bones that were found with them, have been brought to *Dublin*, where I have exa-min'd them particularly, and taken the following correct Sketches.

I am fully convinced, that they muſt certainly have been the *Four Grinding Teeth* in the lower Jaw of an *Elephant*: And that the many looſe Fragments of thoſe large Bones, that were found with them, muſt have been Remains of the ſame *Animal*.

Fig. 28. *Fig.* 28. *A A* is the larger Grinder of the under Jaw on the right Side, weighing two Pounds and three Quarters of a Pound.

b, *b*, *b*, *b*, *b*, *b*, *b*, are white, rough, indented Borders, ſeven in Number, of an irregular Shape, ariſing about the tenth of an Inch higher than the hard black ſhining Surface of the Tooth; this rough raiſed Work ſerves for the bruiſing and grinding the *Animal's* Food, the tough Grains of Rice, Leaves, Fruits, and the Boughs of Trees, and is made of ſo extreme an hard Texture, that it reſembles large knotted Threads of white *Glaſs*, laid on and cloſely faſtned to the dark Superficies of the *Tooth*: And anſwers that glaſſy Surface wherewith Nature has armed the Outſide of the *Teeth* of moſt *Animals*, to prevent their wearing from the conſtant Attrition in Chewing of their Foods.

c, *c*, *c*, *c*, *c*, is that Part of the Tooth which riſes above the Gums, and continues even now diſtinguiſh'd from the reſt of the Bone, by having its Colour of a different Shade.

d, *d*, *d*, *d*, *d*, *d*, *d*, are many ſtrong Tangs or Roots, ſeemingly united all together, by which the Tooth received its Senſe and Nouriſhment, and though it was ſo large and ponderous, by theſe it kept firmly fixt into the Jaw.

For the Mechaniſm Nature ſhews itſelf to have followed in framing the *Teeth* of this *Animal*, is no more than this: Whereas in other Creatures, ſhe has divided that bony Subſtance wherewith they chew their Food, each having its peculiar Roots to ſecure its Articulation in the Jaw-bone; ſhe has in this of ſo great Bulk, for the greater Strength, Stabiliment, and Duration of its *Teeth*, and the better to provide for a compleat Attrition of the Aliment, in order to perfect the Digeſtion ſo thoroughly, as to ſuſtain the Life of the Animal for two or three hundred Years, (as it is a common received Opinion in the *Eaſt*) ſhe has, I ſay, contrived to make the Subſtance of the *Teeth* in their Roots below, and in their upper Parts above the Gums, cloſely unite together; and coaleſcing thus, form a few large maſſy Teeth inſtead of many ſmall ones.

As for Inſtance, in *Man's Body*, that is of ſo much a leſs Size, the Number of the Teeth, (when the whole Sett is compleat) reckons to thirty-two; whereas in the large *Elephant*, the Teeth of both the Jaws amount in all but to Eight, beſides its two great Tuſks, which rather ſerve as Horns for its Defence, than Teeth to prepare its Food; and therefore I think not ſo very properly call'd Teeth.

Fig. 29. *Fig.* 29. *E*, *E*, is the ſmaller *Grinding Tooth* of the under Jaw on the ſame Side; its Surface covered over with the ſame white indented Work, as before deſcribed for grinding of the Food.

f, *f*, *f*, are three large Roots, that kept it firmly fixed in the Jaw-Bone.

This ſmaller Tooth weighed full ſix Ounces.

Fig. 30. *Fig*. 30. *G, G*, is the large *Grinder* of the under Jaw on the left Side, much of the Size, and Shape, and Weight, with its fellow Tooth, deſcribed *Figure* 28. It ſhews its Roots and all its Parts, with the rough protuberant white Work on its upper Surface made after the ſame Contrivance, and formed after the ſame ſtrong Model as the former.

And truly if one conſiders it, 'tis plain, that were not the *Teeth* of this Creature made of ſo large a Size, and withal of ſo maſſy and firm a Subſtance, 'twere abſolutely impoſſible they could reſiſt the Force, and bear all that Preſſure, wherewith thoſe vaſt Muſcles exert themſelves, that move the lower Jaw in Maſtication, in this ſo ſtrong an Animal.

Fig. 31. *Fig*. 31. *H, H*, is the ſmaller *Grinding-Tooth* of the under Jaw on the ſame Side; it is leſs compleat than the ſmall Tooth deſcrib'd before in *Fig*. 29. for ſome of the Root is wanting, and Part of its outward grinding Surface is broke off at *k, k*, ſo that it weighs ſomewhat leſs; yet what remains, exactly ſhews the ſame kind of Work and Shape of the other Tooth, that anſwer'd it on the right Side.

Theſe *Four Teeth* here deſcrib'd, fully compleat the Set of the Teeth, wherewith Nature has furniſhed the lower Jaw of the *Elephant*; and are anſwered by juſt as many more, formed after the ſame Manner in the upper Jaw, as Dr. *Moulins* informs us, who diſſected the *Elephant* that was burnt at *Dublin* in 1681. In its Anatomy, *p*. 40. ſpeaking of the Teeth, he aſſures, there were beſides the Tuſks, only four Teeth in each Jaw, two in every Side; and that theſe eight Teeth were all *Molares*, ſo that he had no *Inciſores*.

But notwithſtanding this, perhaps it will be ſaid, we may not haſtily conclude from hence, that our *Great Teeth* dug up in *Ireland*, muſt certainly have been the *Four Grinders* of an *Elephant*, ſince they might as well belong to ſome other large kind of *Terreſtrial* or *Marine Animal*. As for the Hint of their being *human* or *gigantick*, 'tis ſo groundleſs a Thought, and ſo contradictory to *comparative Anatomy*, and all *Natural Hiſtory*, it does not deſerve our Conſideration.

To obviate this, I take Notice firſt in general, that the differing Kinds of living Creatures, wherewith Nature has ſtock'd the World, are not more diſtinguiſhed by the Make of any Part of their Bodies from one another, than by the various Shape and Diſpoſition of their *Teeth*: And hence it is, we ſhall not find any two diſtinct *Claſſes* of *Animals*, that do exactly agree in the ſame Make and Ranging of their Teeth.

But to be more particular, I ſhall here ſet down at length, the Words of two late Authors, that purpoſely have deſcribed the *Teeth* of the *Elephant*.

Dr. *Blair*, in his Deſcription of the Teeth of this *Animal*, ſays, *Dr.* Moulins *well obſerves, that they are all* Molares, *being two Inches broad in that Part of them wherewith they grind, and ſix Inches and a half* *Vid.* Infra, V. v. p. 117.

long on the Right Side, and five Inches and a half on the Left. Their Surface, though flat, is yet very unequal, for they have alternately placed, running from the Right to the Left Side, an Hollowneſs and then an Eminence; and this Eminence is ſurrounded by a rough protuberant Border. There are nine of theſe Hollowneſſes, and as many Eminences, undulated as they paint Sea Waves.

'Tis remarkable, how very exactly all this agrees with our Figures: 'Tis true, thoſe *Hollowneſſes* and *Eminences*, which he mentions to be *nine*, do not ſo nicely hit with the Number of thoſe in our *Teeth*; but this Difference proceeds from hence, that he deſcribes here the Grinders of the upper, whereas ours are the *Teeth* of the lower Jaw; though ſuch a Diſtinction as this, I am apt to think, may very well ariſe even in thoſe of the ſame Jaw, in various Animals, from ſome peculiar Diſpoſition in one from another, nay, and perhaps in the ſame Animal, at different Times, according as it happens to be older or younger.

* *Vid.* infra. V. v. p. 121. A little farther * where he gives an Account of thoſe of the under Jaw, he ſays,

The hind Tooth of the Right Side is four Inches, and that on the Left five; the one half of their Surface, where they begin to appear above the Gums, is ſemicircular, with the forementioned Ridges and Sulci *running tranſverſly, four on the Right Side, and five on the Left; the other half* (or Tooth I ſuppoſe he means) *has five of theſe Eminences where it grinds on the Right, and four on the Left: Each of the four Teeth is ſix Inches long, and has ſix or ſeven of the forementioned Eminences, and as many Depreſſions: Theſe Teeth are the moſt firm, ſolid, and weighty Bones, of any Animal yet known.*

Mr. *Ray* in his *Synopſis Animalium Quadrupedum*, when he comes to give us the Deſcription of the *Elephant*, has the following Words: *Os pro mole Belluæ parvum, quatuor in utrâque maxillâ Dentibus molaribus ſeu Dentium molarium Maſſis inſtructum*; *ſiquidem* plurimi Dentes in Os ſolidum & durum *ita infixi ſunt, ut cum eo & inter ſe* unum & continuum Corpus *efficiant. Dentes hi lineas parallelas undulatas octo vel novem in ſuperficie maſſæ efficiunt*; *ſuntque reliquo oſſe* candidiores: *Maſſæ integræ, Dentium ſingularium modo, per Gomphoſin maxillis inſeruntur. Inciſoribus omnino caret.*

Thus Mr. *Ray* deſcribes the *Teeth* of this *Animal*: And if we compare Dr. *Blair*'s Words with his, and the Particulars of both Accounts with the Deſcription and Figures we have given of the *Teeth* dug up in *Ireland*, and obſerve how they all agree exactly, even ſo as one may ſay they tally together; I think it will amount to nothing leſs than Demonſtration, and that all our *Ideas* have been taken from one and the ſame *Natural Object*; and as they, ſo we, muſt certainly have deſcribed no other *Teeth* but thoſe of the *Elephant*.

But then perhaps it will be aſk'd, what is become of all the reſt of the *Teeth*, that were in the upper Jaw, which being as firm and ſolid Bones, as thoſe that are here preſerved, might for the ſame Reaſon have ſtill remained entire.

But ſince we find it otherwiſe, 'tis obvious to imagine a probable Conjecture, how this might come about. From what Mr. *Nevil* mentions, 'tis plain that the Bed where all theſe Bones were found, muſt once have been the outward Surface of the *Earth*, the *Green-Sod*, producing *Ruſhes*, *Ferns* and *Nuts*: And when the heavy Beaſt firſt fell dead upon this Spot, the Skull, with all the Bones and Teeth of the upper Jaw, being the higheſt Parts of the *Animal*, might likely fall in ſuch a Poſture, as to be expoſed ſome while above the *Earth*; though thoſe of the under Jaw firſt coming to the Ground, might make themſelves a Bed, and being covered with the Mould, remain preſerved; whilſt the upper Teeth, and moſt of the other Bones, lying expoſed to the Injuries of the Air and Weather, before they got a Covering, might rot and quickly moulder all away.

But though this be allow'd, yet ſtill a greater Difficulty remains unſolved; how this large-body'd *Animal*, a *Native* of the remote warm *Climates* of the *World*, ſhould be depoſited in this wild *Northern Iſland*, (where *Greeks* or *Romans* never had a footing) ſo many Miles from Sea, and diſtant from thoſe Places of the Iſle, where People might moſt probably reſort.

And to make the Difficulty yet greater, we muſt conſider, not only from the dark black Colour of the Teeth, contracted by their lying long under Ground, and the remarkable Alteration wrought on their bony Subſtance, which (by the mineral Steams and Exhalations it has imbib'd whilſt it was in the Earth) is now become more ſolid, hard, and ponderous, than it was naturally at firſt, (nay, in ſome Parts we find it plainly petrified) but alſo from the periſhing of all the other Bones of the Animal's Body, and from the conſiderable *Depth* of *Earth* that covered thoſe that were found: We muſt conclude from hence, that they have lain in this Place for many Centuries: I won't ſay, with Mr. *Nevil*, ever ſince the *Flood*, becauſe I can't ſuppoſe that the ſlight Texture of vegetable Subſtances, *Nuts* and the Seeds of *Ruſhes*, could poſſibly have been preſerved ſo long: But this, at leaſt, may ſafely be affirmed, that theſe Remains muſt be Cotemporaries with ſome of the remote Ages of the *World*; which carries us ſo far back into the earlieſt Times, that we can never imagine the rude Inhabitants of *Ireland*, or any of their neighbouring Countries, were Maſters of ſo much Art, in thoſe Days of Ignorance and Darkneſs, as to make Carriages by Sea ſtrong and capable, or of Curioſity and Politeneſs enough, to tranſport a Beaſt of this large Size from thoſe far diſtant Countries, where 'twas bred.

Theſe Conſiderations, grounded on other Inſtances of the like kind, make me inclined to think, this *Elephant* might not be brought hither by any Care or Induſtry of *Man*; but the Surface of this Terraqueous Globe might, in the earlieſt Ages of the *World*, after the *Deluge*, but before all Records of our oldeſt *Hiſtories*, differ widely from its preſent *Geography*, as to the Diſtribution of the *Ocean* and *Dry-land*, its *Iſlands*,

Iſlands, *Continents*, and *Shores*, ſo as to allow this Beaſt, and others of its Kind, for ought I know, that may by ſome ſuch Accident hereafter be luckily diſcovered, a free and open Paſſage into this Country from the Continent.

For otherwiſe, how can we ever explain that that other vaſt large ſtately *Animal* the *Mooſe-Deer*, little inferior to the *Elephant* itſelf, could have been brought to *Ireland*, (where elſewhere I have ſhewn it formerly was common) from diſtant *North America*, even long before that Quarter of the World was known, and is the only Region, I can hear, where this great Beaſt is found at preſent.

And can we well imagine, that *Foxes*, *Otters*, *Badgers*, *Tygers*, *Wolves*, with *Linxes*, and ſuch ravenous *Animals*, as we have been told, have lately been diſcovered by the great Snows that fell this preſent Winter, in the *Iſland* of *Sardinia* and other Places, ſhould ever be imported (being uſeleſs noxious Beaſts of Prey) by the Induſtry of *Man*, to propagate in *Iſlands*?

Nay, how can we ſuppoſe, that *Birds* of ſhorteſt Flight, the various ſorts of poiſonous *Serpents*, and of offenſive *creeping Vermin*, with all the various Tribes of ſmaller *Inſects*, could poſſibly be found in *Iſlands*, unleſs they had been ſtock'd with thoſe Inhabitants, when the Intercourſe between them and the Continent was free and open?

But in whatever Manner this *Elephant* might firſt have made its way for *Ireland*, this is beyond Diſpute, that the *Bones* of *Elephants* have been diſcovered deep under Ground, in other Places, as well as this Kingdom, and thoſe too out of the Way, far diſtant from the native Countries of this Animal.

For not many Years ago, in a Hill near *Erfurt*, a Town of the *Upper Saxony* in *Germany*, ſeveral Parts of the *Skeleton* of an *Elephant* were dug up; an Account of which is given by *Tentzelius* *.

And I am well perſuaded, by the beſt Conſtruction I can make of thoſe imperfect and obſcure Accounts, we have in *Evert Iſbrand Iddes* curious Travels from *Muſcovy* to *China* over Land, *Chap*. 6. (which he confeſſes he only gather'd from the barbarous *Oſtiacks*, Inhabitants of that Country) concerning the vaſt *Teeth* and *Bones* and *Limbs* of **Mammuths**, as he calls them, frequently found (and diligently ſought after to make Profit of them) in the Hills and Banks of ſeveral Rivers in *Siberia*, the *Keta*, *Jenize*, *Trugan*, *Montgamſea*, and *Lena*; that they are nothing elſe, but the Remains and *Skeletons* of *Elephants* buried there, and accidentally diſcovered by the Earth's opening, and falling down, on the ſudden Thaws, after ſevere long Froſts.

Mr. *Cambden* in his *Britannia* is of Opinion, that thoſe great monſtrous *Teeth* and *Bones*, which he takes Notice to have been at ſeveral Times dug up in many Parts of *Great Britain*, muſt have been the Remains of *Elephants*; but then he thinks, they muſt be of thoſe that *Dion Caſſius* the Hiſtorian tells us the *Roman* Emperor *Claudius* brought over, when he made his Expedition into that *Iſland*. But that this truly is ſo, I own is but Surmiſe as yet, and has not been fairly proved by him or any other.

---

* *Vid.* ſupra, V. II. C. III. S. XXXVIII.

What Mr. *Somner* * has publiſhed is more remarkable; he informs us, that in the Year 1668, in the Village of *Chartham* near *Canterbury*, in *England*, *digging within twelve Rods of a River, they found a Parcel of ſtrange monſtrous Bones, ſome whole, ſome broken, together with four Teeth, perfect and ſound, each weighing ſomething above half a Pound, and ſome of them almoſt as big as a Man's Fiſt. They are all Cheek Teeth or Grinders; the Earth in which they lay being like a Sea-Earth, or Fulling-Earth, with not a Stone in it.*

'Tis obſervable how this Account, in many of its Circumſtances, agrees with that of Mr. *Nevil*'s; as that the Teeth were all Grinders, four in Number, found with other large broken Bones, near a Brook, and in a claiey Earth, without a Stone: But then the Weight and Magnitude of our largeſt *Teeth* ſo far ſurpaſs thoſe, that were found in *England*, that theſe did not come up to a fifth Part of thoſe, which ſhews, they could not be the Teeth of the ſame Animal. I muſt confeſs, the Author does not ſo much as ſuſpect they were *Elephants Teeth*, but on the contrary, is of Opinion that they belong'd to another *Species*, the *Hippopotamus* or *River-Horſe*, a Beaſt that's yet a greater Stranger in theſe Parts of the World, than the *Elephant* itſelf; and therefore its Paſſage hither can never be accounted for, but by ſome ſuch like Suppoſition, as we have made.

Mr. *Luffkin* † differs in his Judgment from Mr. *Somner* about theſe Teeth, which he thinks muſt have been *Elephants Teeth*; as he is poſitive thoſe large Bones he deſcribes in the ſame Letter, and found near *Harwich* in *Eſſex*, certainly muſt have been.

Not having ſeen any of the Bones or Teeth concern'd in this Controverſy, either thoſe that were found in *Kent*, or thoſe in *Eſſex*, I cannot well take upon me to determine any thing in this Matter: But this at preſent I can ſafely ſay, that if the *Figures* of the *Teeth* given us by Mr. *Somner* ‖ be genuine and well expreſt, they no way ſeem to agree either in Shape or Make, or in that particular and *Characteriſtick* Work on the grinding Superficies, with the *Teeth* of the *Elephant*; or with the Deſcription and Figures we have given, which are correct and natural.

I am inclined to think, (even from theſe imperfect Hints) that if we had more correct Hiſtories and Obſervations of this kind, made in diſtant Countries, ſkilfully regiſtred, with all their inſtructive Circumſtances, they might lead us into great and momentous *Truths* relating to the *Deluge*; to the wiſe Methods of Providence, in repleniſhing all Regions of the *World* with *Animal Beings* ſoon after the *Flood*; and to the Knowledge of ſeveral important Changes, that may have happen'd on the Surface of this our *Terraqueous Globe*.

[*The Tooth* Fig. 34. *is* Nine *Inches and a* half *long, whereby the Magnitude of the others may be eſtimated.*]

This

* *Vid.* ſupra. p. 222.

† *Vid.* infra. p. 245.

‖ *Vid.* Fig. 26, 27.

Remarks by *Dr.* E. Halley. *ibid.*

3.] This Account of Mr. *Nevil*'s, with Mr. *Molyneux*'s Draughts of the Teeth, and his Remarks upon them, having been produced and read before the *Royal Society*, they order'd, that what Teeth they had of like ſort ſhould be look'd out and laid before them; to which Sir *Hans Sloan* was pleaſed to furniſh a yet greater Variety, out of his Collection of *Natural Rarities*. And to obviate all Doubts, there being at this Time in *Weſtminſter* the entire Skull of a large Elephant with the Teeth in it, That was likewiſe ordered to be viewed and compared with the Figures: Which done, it appeared that the Teeth in Queſtion could be no other than thoſe of an Elephant.

By this Enquiry we were likewiſe ſatisfied, that the Number of Teeth found being but four, was no Objection; it appearing that the Number of *Molares* in this Animal is not certain. *Pliny*, *Lib.* XI. c. 37. ſays expreſly, *Dentes Elephanto intus ad mandendum quatuor, præter eos qui prominent.* And in the Remains of that mighty Elephant deſcribed by *Tenzelius* *, there were no more than four Teeth found. In that at *Weſtminſter* there were ſix, *viz.* one in each lower Jaw, and two in each of the upper, whereof the inner Tooth is about three Times as long as the other, and both together longer than thoſe of the under Jaw, by about an Inch; the upper ſmall Teeth being much worn by grinding. Theſe we have thought fit to repreſent by *Fig.* 32. ſhewing the rough grinding Surface of the left under Tooth, being conſiderably *concave*; and by *Fig.* 33. the ſame Roughneſs on the upper Teeth is ſhewn, having a *Convexity* tallying with the *Concavity* of the under, which is a Circumſtance not obſerved by any of thoſe that have deſcribed them.

* *Vid.* ſupra, V. II. C. III. S. XXXVII.

Fig. 32.

Fig. 33.

And altho', by the Obſervation of Mr. *Du Verney*, Dr. *Moulins*, and Dr. *Blair*, who diſſected three different Elephants, it appears, that each of them had eight *Molares*; yet from theſe it is alſo evident, that in the Diviſion of them Nature obſerves no Rule: For Dr. *Moulins* found the two Teeth, in each of the upper Jaws of that he diſſected, to be divided after a different Manner; ſo that the inner Tooth on the one Side, and the outer on the other, was bigger than its adjoining Fellow, yet not ſo as to be very unequal: And Mr. *Du Verney* and Dr. *Blair* had on both Sides the much greater Tooth outwards: Whereas the *Weſtminſter* Skull, on the contrary, has only a ſmall one outwards, and the much greater Grinder within. All which conſidered, we may with Aſſurance conclude, that this Elephant found in *Ireland* had but four Teeth in his Head when he died; and that the two greater were thoſe of the upper Jaws, and the other two thoſe of the under.

Again, by the Size of the grinding Part, we may conclude theſe to be the Teeth of a very young and ſmall Elephant; ſince they are not much above half the Length of thoſe, that are to be ſeen at *Weſtminſter*, which belonged to a Beaſt of not more than between 10 and 11 Feet high; nor much above one Third of the Length of a Foſſil Elephant's Grinder in the *Royal Society*'s Repoſitory, the which is here repreſented by *Fig.* 34. Hence it is not to be wondered at, that the

Fig. 34.

Bones of ſo young an Animal, having not acquired their Firmity, as being in a growing State, ſhould be diſſolved by long lying in the Earth, as alſo the Roots of the Teeth.

Matthew Paris in his Hiſtory aſſures us, that in his Time *Louis* IX. (afterwards St. *Louis)* King of *France*, made a Preſent of an Elephant to his Cotemporary *Henry* III. of *England*, and that in the Year 1255, after the *Engliſh* had been fourſcore Years Maſters of *Ireland*. Of this, ſays *Matthew*, *Nec credimus, quod unquam aliquis Elephas viſus eſt in* Angliâ, *præter illum.*

An Account of Large Bones *found near* Colcheſter, *by Mr.* J. Luffkin n.274.p.924.

X. Having read Mr. *Somner*'s Account of ſtrange Bones found at *Chartham*, I think it not improper to acquaint you with ſomething like it: That in 1701, at *Wrabneſs*, a ſmall Village, ſituate in the moſt Eaſtern Parts of *Eſſex*, upon the River *Stour*, near *Harwich*, divers Bones of an extraordinary Bigneſs were found at fifteen or ſixteen Feet beneath the Surface of the Earth, in digging for Gravel to mend the Roads with, *&c.* the largeſt and moſt remarkable of which was procured and ſent to me by Mr. *Rich*, Miniſter of the Place.

We read in *Cambden*, p. 351. that in the Time of King *Richard* II. and in the Reign of Queen *Elizabeth*, there were found in the moſt Eaſtern Promontory of *Eſſex*, at a Place call'd *Odulſineſs*, which I take to be *Walton*, large Teeth, and Bones of an extraordinary Bulk, which were eſteemed the Bones of Giants. But Mr. *Childrey* in his *Britannia Baconica*, p. 100. rather thinks them to be the Bones and Teeth of ſome Elephant, buried there by the *Romans*.

That theſe were the Bones and Teeth of ſome Elephant, I am prone to believe; firſt, becauſe they far ſurpaſs in Magnitude the Bones, *&c.* of the largeſt Creatures that we have at this Day in our Iſland.

Secondly, becauſe 'tis evident from *Dion Caſſius*, as quoted by Mr. *Cambden*, (ſee the *Romans* in *Britain*, and in his *Britannia*, pag. 347.) that Abundance of Elephants were brought over into *England* by the Emperor *Claudius*, in his Wars with the *Britons*; even into *Eſſex*, as appears from the ſame *Dion*, a little after in theſe Words: *Claudius* having at laſt joined *Plautius*, and took the Command of the Army, paſſed the River (meaning the *Thames)* and upon a fair Engagement with the Enemy, who were poſted there to receive him, obtained the Victory, took *Camalodunum*, &c.

Thirdly, in comparing this Bone with the Oſteology of Dr. *Moulins*, in his Anatomical Account of the Elephant burnt at *Dublin*, &c. I find it perfectly to agree to and with the *Os humeri* thereof, not only to outward Appearance or Form, but to Meaſure alſo; from which Circumſtances we may conclude, that theſe were the Bones, *&c.* of ſome Elephant, rather than of any other Animal.

And it does ſeemingly appear to me, that theſe Teeth and Bones mention'd by Mr. *Somner*, might have been the Teeth and Bones of ſome Elephant, rather than that of the *Hippopotamus*: and that, Firſt, in reſpect of the Place; for, as Mr. *Cambden* ſays in his *Britannia*, p. 197. ſpeaking of *Chilham* in *Kent*, of which this *Chartham* is a neighbouring Village, ſituate in the ſame Down, and on the ſame River *Stour*, that it is a current Report amongſt the Inhabitants, that *Julius Cæſar* encamp'd there, in his ſecond Expedition againſt the *Britons*; and thence it was called *Julham*, as if one ſhould ſay, *Julius* Station or Houſe.

It appears farther, *Britan.* p. 208. that *Rhutupiæ* (which whether *Richborough* or *Stoner* matters not) ſituate near the preſent *Sandwich*, was the Place of *Claudius*'s landing in *Britain*; and that through this Down was his neareſt Paſſage to the *Thames* whither he was going, is indiſputable. So that 'tis highly probable, that during the Stay, paſſing or repaſſing of theſe *Roman* Armies through theſe Downs, ſome one of their Elephants might periſh or die, and be buried there.

Secondly, By the Teeth themſelves, for if you compare the Icons given by Mr. *Somner*, with the Deſcriptions of Dr. *Moulins*, p. 40. you will find them the very ſame as to Breadth and Depth, &c. and their being *Molares*; for, ſays the Doctor, theſe eight (which were all the Elephant had, beſides the two Tuſhes) were *Molares*, for he had no *Inciſores*.

And laſtly, to ſolve that great Difficulty which obliged this Gentleman to imagine this Down to have been an *Æſtuary*, that his *Hippopotamus* might therein dig itſelf a Grave, otherwiſe how ſhould theſe Bones be found at ſuch a Depth? For who with Reaſon (ſays Mr. *Somner*) can imagine, that any Land Creature could ever have had (at firſt) ſo deep a Burial?

But 'tis eaſily explained, why theſe Bones ſhould at this Day be found at ſuch Depths, if we conſider the Alteration or Riſing of the Vallies, by the continual waſhing down of the looſe Earth or Soil by the Rains and Snows from the adjacent Hills, and by the annual Rollings of the Graſs, Sedge, &c. for Proof whereof take the following Inſtance from Dr. *Plott*'s Nat. Hiſt. of *Staffordſhire*, Chap. vi. p. 48. p. 220. ſpeaking of a Moſs, &c. wherein there was found a Lump of Coins of *Edward* IV. of *England* (ſuppoſed to be loſt in a Purſe or Cloth now rotted away) at 18 Feet deep, which being about 200 Years ſince (that is, when they were found) whoever pleaſes to compute it, will find this Moſs grew about one Foot in 11 Years, or one Inch *per Annum* and $\frac{1}{11}$ *proximè*. Divers other Inſtances of Alteration are mentioned in the ſame Hiſtory, as in Chap. 3. par. 11, 12. and Chap. 6. par. 45, 46, 47, 48, &c. Now it will be eaſily granted, that if this Moſs grew or advanced itſelf above its Surface 18 Feet in 200 Years, then this Vale or Down might advance itſelf 17 Feet in almoſt 1700 Years.

Coins, &c. *found* under Ground *in* Lincolnſhire, *by* — n. 279. p. 1156.

XI. 1.] In *July* 1701, one *Edward Lenton*, who lives with one *Philip Wolverſton* of *Fleet* in *South Holland* in *Lincolnſhire*, being about to fence in a Hay-ſtack, and digging a Grip for that Purpoſe about the Depth of half a Yard, ſtruck his Spade upon a Pot, which when he broke, there was no leſs than 36 Pound Weight of old *Roman* Copper Coin found in it. The Pieces were found ſet in Rows edge-ways, one by another, and ſtuck ſo together with the Verdigreaſe or Ruſt of Copper, that many of them required a Chizel, or ſome ſuch Thing, to ſeparate them; but being ſeparated, clean'd and brighten'd, the Heads or Figures of all, or moſt of them, were very fair, (ſome as when newly ſtamped) and the Inſcriptions of many are very legible. The Fellow careleſly gave them away, and diſperſed them up and down the Country to ſuch as deſired them. Here was amaſs'd together a great Variety of Coins in this Pot: They ſay Dr. *Hart* of *Wiſhich* has a Dozen of the beſt Pieces; and an Apothecary at *Long Sutton* a Score of the ſame, the largeſt and moſt legible: And *Philip Wolverſton* himſelf has two or three, ſo very large and fair, that he will not part with them. The Place where they were found, is in the midſt of the vaſteſt Flat or Level in *England*, and in a Ground that for many Ages paſt uſed to be cover'd with Water in the Winter, and over-grown with Reed in the Summer. 'Tis about a Mile and a half South *by* Weſt from *Fleet-Church*, and about as far South *by* Eaſt from *Holbeach*. There are no Banks or Hillocks, old Works or Ruins, to be ſeen near it; nor any Remains or Tokens of any Thing extraordinary to have been there; (but the old Sea Bank about two or three Miles off; which *Dugdale* from a Paſſage in *Tacitus* believes to be caſt up by the *Roman* Soldiers). But all is as flat as the Sea, and a low Country, producing a coarſe flaggy Graſs for the moſt part, round about it. The Pot, which was narroweſt at the Top and Bottom, but thicker in the middle, had an Inſcription about it, which, though it ſeemeth in ſome of the Shreds or Pieces to be fair at firſt Sight, yet is not legible, though what it may be to Men ſkill'd in Antiquities, I know not.

Boats, Ox-horns, &c. Near the River *Welland*, (about 5 or 6 Years ago) that runs thro' the Town of *Spalding* in *Lincolnſhire*, at the Depth of above eight or ten Feet, there were found *Jettys*, as they call them, to keep up the old River's Bank, and the Head of a Tunnel that emptied the Land-water into the old River; and at a conſiderable Diſtance from the preſent River, I gueſs 20 or 30 Yards, there were dug up (about the like Depth) ſeveral old *Boats*; which Things ſhew, that anciently the River was either much wider than now it is, or ran in another Place, or both. On the other, *viz.* the North-Weſt Side of the River, and more upwards in the Town, were digg'd up (at about the aforemention'd Depth) the Remains of old *Tan-vats* or *Pits*, a great Quantity of *Ox-horns*, and *Shoe-ſoals*, (of a ſtrange Form) and I think the very Tanners Knobs, *&c.* which Things ſhew, that the Surface of the Country lay anciently much lower than now it does, and has been raiſed by the Sea's throwing in its Sand in the Maritime Parts (now moſt inhabited) and by the *Moor* or *rotted Sedge* in the fenny Parts next the high Country; the whole Level is about 50 Miles in Length, and 30 Miles over in the broadeſt

Parts. No Record (printed or MS.) or Tradition whatſoever, (that I ever heard of) tell us when theſe Mutations here diſcoverable happen'd.

One Thing farther I have to add, that lately at the laying of the preſent new Sluice or *Goat* (as they call it) at the End of *Hamorebeck*, at its Fall into *Boſton* Haven, taking up the Foundation of the old *Goat*, they met with the *Roots of Trees*, many of them iſſuing from their ſeveral *Poles* or *Trunks*, ſpread in the Ground, which when they had taken up (Roots and Earth they grew in) they met with a ſolid, gravelly, and ſtony Soil, of the high Country Kind, (but black and diſcoloured by the Change that had befallen it) upon which hard Earth they laid the Foundation of this new *Goat*: Where theſe Roots were dug up, was certainly the Surface of the old Country, the certain Depth whereof I cannot now tell, but that it was much deeper than that at *Spalding*, as the Land is there at preſent higher. The *Archimedean* Screw, or ſcrew-like Trunk or Cylinder, by which the Workmen cleared themſelves of Water, was very pretty.

A Remark, *by Mr.* R. Thoreſby. *ibid.*

2.] The Matter of Fact in theſe Relations, is indiſputable, this worthy Perſon being an Eye-witneſs; and I take it for an experimental Confirmation of Mr. *Ray*'s Opinion, that the great Level of the Fens running through *Holland* in *Lincolnſhire*, the Iſle of *Ely* in *Cambridgeſhire*, and *Marſhland* in *Norfolk*, was ſometime part of the Sea, and atterated by Earth brought down by Floods from the upper Grounds, by the great Quantity of Mud there ſubſiding, which by degrees raiſed it up. The Form of the *Shoe* was much like thoſe found with ſome Urns at *Kirby Thore* in *Weſtmoreland*, as deſcrib'd in *Ph. Tran.* N° 158.*

* *Vid.* ſupra, V. III. P. II. S. XXVI.

Of an uncommon Sinking *of the* Earth, *by Mr.* J. Sackette. n. 349. p. 469.

XII. I ſhall give the beſt Account I can, of what is remarkable, and known to almoſt all hereabouts, concerning the preſſing forward of the Cliffs, and ſinking of the Hills in the Neighbourhood of the Town of *Folkſtone* in *Kent*. I ſhall give a Sketch of the Situation of the Country, by deſcribing a ſtraight Road from what we call the *Mooring-Rock*, to *Tarlingham-Houſe*; the Manner of the Country, as to the Riſing and Falling, being much the ſame, for about a Mile on either Hand of the Road deſcribed.

Fig. 35. *A*, the *Mooring-Rock*, about half way between High and Low-Water Mark. *B*, the Foot of the Cliff, 50 Yards from the Rock. *C*, the Top of the Cliff, about 6 Yards high. *C D*, a Plain of 50 Yards. *D E*, a cragged Cliff, of 60 Yards high. *E F*, a Plain above a Mile long. *F G*, an Hill of ſteep Aſcent, near half a Mile. *G H*, the Land from the Top of the Hill to the Houſe, near a Mile. *I*, *Tarlingham-Houſe*, lying near two Miles and a half N. N. W. from the Rock. *E G H*, a Line of Sight. *K B L*, the Shore at High-Water Mark.

The *Mooring-Rock* (though it lies ſurrounded with great Numbers of other Rocks) is itſelf a moſt noted one, known by this Name, Time out of Mind. At this Veſſels uſe to be moored, while they are loading other Rocks, which they take from hence, not only for our own *Pier-Heads*, but for thoſe of *Dover-Pier*, and a very great Quantity of them were ſhipp'd in the Time of *Oliver*'s Uſurpation, and carried to *Dunkirk*, for the Service of that Harbour.

This Rock has remain'd fix'd thus, for the Memory of Man; and old Men have obſerved, that for forty Years and upwards, the Diſtance between it and the Foot of the leſſer Cliff *A B*, has been much the ſame; neither can they be much out in their Gueſs, the Diſtance being ſo ſmall. Though there ſeems nothing extraordinary in this, yet its what they take ſpecial Notice of, to their great Surprize: For they ſay, and prove by good Marks and Tokens, that the leſſer Cliff *B, C*, has been conſtantly falling in, inſomuch, that from Time to Time, in their Memory, near 10 Rods forward to the Land has been carried away by the Sea. From whence, as it appears that the Plain between the Top of the leſſer Cliff and the Foot of the higher *C D*, has been formerly double the Breadth that it is at preſent, ſo the Diſtance between the Rock and the Foot of the leſſer and lower Cliff *A B*, ſhould have increaſed in Proportion, and would have been double at preſent, to what it has been formerly. But this Diſtance remaining the ſame, or rather leſs, (in the Opinion of many) is what is greatly wonder'd at: Nor can it be accounted for otherwiſe, than by ſuppoſing, that the Land preſſing forward into the Sea, is waſhed away by the high Tides; and, as often as this happens, preſſes forward again. This preſſing forward of the Land into the Sea, would be incredible, were it not ſhewn to be Matter of Fact; and that not only at this one Place of Obſervation, but by the like Obſervations all along this Coaſt, as far as the Situation continues the ſame.

Now let us climb both theſe cragged Cliffs, and place our ſelves at the Top of the higher one, at the Point *E*. And here we are to obſerve, that (as old Men inform us) upward of forty Years ago, not ſo much as the Top of *Tarlingham-Houſe* could be diſcern'd, neither from hence, nor yet a good Diſtance off at Sea; but it diſcover'd it ſelf by Degrees; till at this Day, not only the whole Houſe, but a great Tract of Land below it, is plainly to be ſeen, as in the Line of Sight *E, G, H*. In this there can be no Fallacy, and we can aſcribe it to nothing leſs than the ſinking of the Hills (for their Tops could never wear away conſiderably, being always cover'd with Graſs, and never broken up by the Plough, or otherwiſe). Theſe Hills are all of Chalk, and have probably very large Caverns within, Springs of Water always flowing plentifully from the Foot of them; and I have had it obſerved to me, that upon their Tops frequent Cracks have been taken Notice of. Whatever be the Cauſe of it, 'tis not to be doubted, but that theſe Hills are greatly ſunk. And this ſinking of the Hills, the People at this Place believe, forces the Cliffs and all the Land forward into the Sea. The Cliffs conſiſt of great ragged Sand-Stones, till we come to near a Yard (at ſome Places more) of the Bottom; then we meet with what they call a Slipe, *i. e.* a ſlippery ſort of Clay always wet.

Upon this Slipe, at the Bottom, they preſume, that the hard ſtony Land above, ſlides forwards toward the Sea, as a Ship is launched upon tallow'd Planks.

We whoſe Names are under-written, do hereby teſtify the Truth of the Matters of Fact in this Account; *Benjamin Maſter*, a Jurat of the Town, aged 74. *Robert Hammond*, Sen. a Jurat of the Town, aged 77. *William Godden*, a Fiſherman, aged 74. *Thomas Marſh*, a Fiſherman, aged 72. *William Hall*, a Fiſherman, aged 73. *James Godden*, a Fiſherman, upwards of 60.

Part of a Hill *ſinking down in* Ireland. *Communicated by the* Biſhop *of* Clogher. n. 337. p. 267. *Fig.* 36.

XIII. Let *S*, *T*, *Fig.* 36. repreſent part of the Ridge of an Hill, gradually riſing from *S* to *T*, for near half a Mile; and *S*, *T*, *W*, *U*, the North-ſide of the Hill, with a Declivity from *S* to *U*, and from *T* to *W*. The perpendicular Height at *X*, to the Plain of the Bottom at *Y*, 150 Feet, and the Slope Line or *Hypotenuſe X*, *Y*, 630 Feet.

The Declivity is pretty uniform from *X* to *L*, and from *L* to *Y* conſiderably ſteeper: The Bank *A*, *E*, *F*, *D*, overgrown with ſhrubby Wood, all the Ground on the Side of the Hill being firm, green, and arable; of a mixed Soil, Clay and Gravel, but more clayey.

On *Tueſday* the 10*th* of *March*, 1712-13, in the Morning, the People obſerved a Crack in the Ground, like a Furrow made with a Plough, going round from *A*, by *B C*, to *D*. They imputed this to (what they call) a Thunderbolt; becauſe there had been Thunder and Lightning on *Monday* Night. But on *Tueſday* Evening an hideous dull Noiſe raiſed their Curioſity; and they obſerved that the whole Space *A*, *B*, *C*, *D*, containing about three *Iriſh* (i. e. 4½ *Engliſh*) Acres, had been all Day in a gentle Motion: And the Noiſe continued all Night, occaſioned by the rubbing of Buſhes, tearing of Roots, rending and tumbling of Earth. The Motion ceaſed on *Wedneſday* after Noon, when they ſaw the Buſhes on the Bank *E F*, were removed, ſome ſtanding and ſome overthrown, to the plain Meadow *Y y*. The green Ground above *E F*, when it came to the Top of the ſteep Part at *E F*, rent with hideous Chaſms, ten, fifteen, or twenty Feet deep, and tumbled down in Rolls of a Yard or two thick, and ten or twenty long and broad; not unlike a ſmooth Water breaking over a Cataract, and tumbling in Waves below.

There was a Precipice at the Top *X x*, 65 Feet perpendicular, making the Slope-Line *X x*, 126 Feet. The Ground from *x* to *L*, was made more level, the whole perpendicular Height of *x* not exceeding the Plain of *L*, above 30 Feet; but the Ground at *L*, in the whole Line from *E* to *F*, was mounted above 20 Feet higher than the unmoved Ground on either Side at *E* and *F*; and the Height of *L*, above the Plain of *y*, is 55 Feet.

There was a Ditch *H I*, went croſs the Ground, which being broken off at *o*, *o*, is removed, together with the moving Part, 34 Feet lower down than the immoveable; but, at the Bottom *y*, it is tumbled 60 Feet over the plain Meadow. The Breadth at the Bottom *a*, *b*, is 400 Feet, and at *c*, *d*, about 300.

The whole Face of the Precipice *X x*, is of a blue Clay, mixed with many little blue Stones. The Metal is very hard when dry; but upon any Rain ſoftens to a kind of Mortar, without the Degree of Toughneſs and Stiffneſs that is natural to Clays. It is very much like that Gravel or Sand (as they call it) which is ſomewhat of a grey marly Nature, and with which of late they ſo much improve the ploughed Land in this Country.

About *x*, there are Chaſms or Gapings full of Water, which make a Rill down the *Hiatus B*, *E*, *A*, but in no greater Quantity, than might have been expected from a Well ſunk to a leſs Depth. Though I was told, that there were Holes in the higher Mountains, that received Water under Ground; yet I can find no ſuch Thing, nor any Symptoms of a Current under Ground, either where it enters or riſes, in all the neighbouring Ground for ſome Miles.

It ſeems to me, that there has been no Vacuity under Ground to receive the ſubſiding Earth; for what the Bank *E*, *L*, *F*, is raiſed higher, and what is tumbled down to the Plain *a*, *b*, may very well compenſate the Subſiding at the Precipice *X*, *x*.

Before the Rupture, the Declivity from *X* to *L*, was not altogether uniform, but was hollower where *x* is now, than the adjacent Parts: It might have been, by the Deſcription I have from the People, 10 Feet deep in the Middle, and 100 Feet Diameter; and they have a Tradition, that this was made by a Subſiding before the Forty-one Wars, (the oldeſt *Epocha* the Country *Iriſh* know.)

It lies in the Lands of *Slat-beg*, two *Engliſh* Miles S. W. of *Clogher*, on Mr. *Mowtray*'s Eſtate.

I have enquired diligently of the Neighbours, if they found any Shocks or Indications of an Earthquake, but don't find the leaſt Appearance of any.

They impute it to the great and conſtant Rains we have had laſt Harveſt and Winter, which have ſoak'd and ſteep'd all the Ground, but cannot gueſs after what Manner they ſhould produce this Effect; for it is impoſſible any Water ſhould ſtand on the Ground, or in the Vicinity, it being all on the Declivity of the Hill.

An Account of the Sunk Iſland, *in the* Humber, *recovered from the* Sea: *Communicated by* J. Chamberlayne, *Eſq*; n. 361. p. 1114.

XIV. This Iſland goes by the Name of the *Sunk* Iſland; ſo called, I ſuppoſe, from the ſinking Marſh Ground about. It is yet within the Memory of Man ſince it began to raiſe its Head above the Ocean, there being ſeveral old People here alive who can remember when there appeared nothing of it but a waſte and barren Sand; and that only at Low-Water too; when for the Space of a few Hours it ſhewed its Head, and then was buried again till the next Tide's Retreat: Thus ſucceſſively it lived and died until the Year 1666, when it began to maintain its Ground againſt the Inſult of the Waves; about which Time it began to be reſcued wholly from future Danger, by the Care and Induſtry of Colonel *Gilby*, who having, as I am inform'd, a Leaſe or Gift of it from the Crown, did raiſe Banks about the riſing Grounds of it, and ſo defending it from the Encroachments of the Water, it became firm and ſolid, and in a ſhort Time afforded good Paſturage for Sheep and other Cattle. The Expences at firſt, to improve it to what it is, muſt needs have been very conſiderable; it being encompaſs'd with high Banks, and deep Canals for receiving and diſcharging the Liquid Element, which every now and then notwithſtanding threatens to repoſſeſs it, but hitherto in vain.

This Iſland is now about 9 Miles in Circumference, within the Banks, which ſeem to render it impregnable againſt all future Attacks of the Sea, and is of a very fat and fertile Soil, affords good Graſs, Corn and Hay, and is repleniſhed with numerous Flocks of Sheep, which are of a larger Size and finer Wool, than thoſe in *Holderneſs*, from which it is divided by about two Miles in Water; and from *Lincolnſhire* by about four. It is ſtor'd with vaſt Numbers of Rabbets, that ſeem innumerable, they appearing through all Parts in prodigious Swarms; their Skins are counted the fineſt in *England*, of a dark Mouſe-Colour, ſhagg'd, and ſoft as Silk.

There are alſo Cows and Horſes feeding conſtantly in the Place, with great Plenty of Wild Fowl.

The Inhabitants are not ſo numerous, there being only three Families, that live conſtantly upon the Place; however they are never too ſolitary, there being Abundance of Workmen and Labourers, that continually reſort thither, ſometimes I am told to the Number of a Hundred and upwards, for the repairing of the Banks, &c.

The yearly Income of the Proprietor amounts to about 800 *l.* and pays the King's Taxes to thoſe who collect for the *Eaſt-Riding*, and is uſually uplifted by thoſe of the Liberty and Townſhip of *Ottringham*, from the Marſhes of which there is a Paſſage over the Sands to the *Sunk* at Low-water. But this Cuſtom of paying the King's Ceſs to them, proceeds from the Conveniency, not Neceſſity; for it never belong'd to that, or any other Pariſh, ſo that I cannot reſolve you, in what Dioceſe this Iſland lies, unleſs it had been united to ſome neighbouring Pariſh, or converted to one of itſelf; which if effected, the Tythe of Lambs, Wool and Rabbets, &c. would make up a handſome Benefice. It lies nearer indeed to the Dioceſe of *York*, by at leaſt two Miles, than to that of *Lincoln*, being two Miles South of *Holderneſs*, in the River *Humber*, and four Miles North of *Lincolnſhire.*

An Account of the Sinking *of* 3 Oaks *into the* Ground: *Communicated by Mr.* P. le Neve. n. 355. p. 766.

XV. On the 23*d* of *July* 1717, near the Seat of Sir *Charles Potts* at *Manington* in *Norfolk*, in the Day Time, to the great Aſtoniſhment of thoſe that were preſent, firſt one ſingle Oak, with the Roots and Ground about it, was ſeen to ſubſide and ſink into the Earth; and not long after, at about 40 Yards Diſtance, two other Oaks, that were contiguous, ſunk after the ſame Manner into a much larger Pit, being about

33 Feet

Plate III. Vol. IV. Part II. Page 252.

Fig. 32.

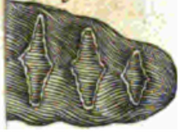


Fig. 33.

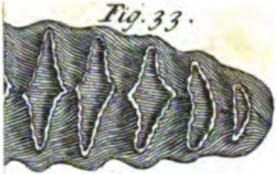
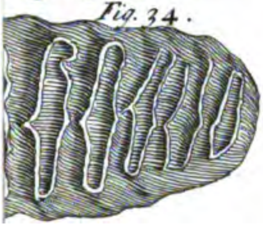
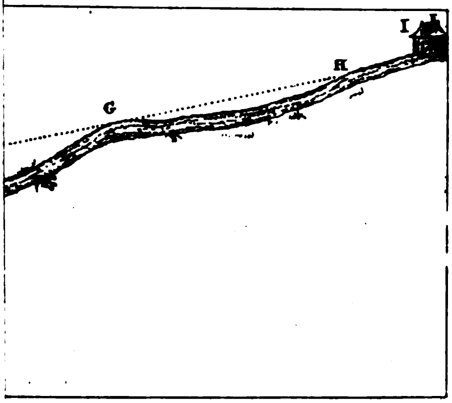


Fig. 34.





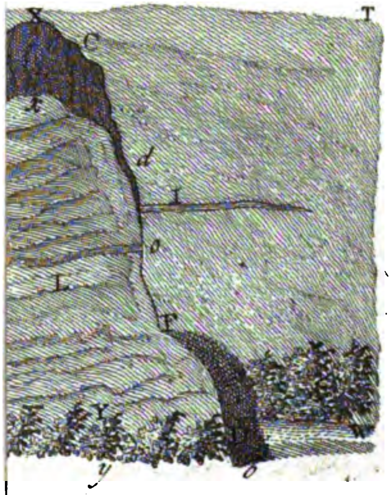


Fig. 30.

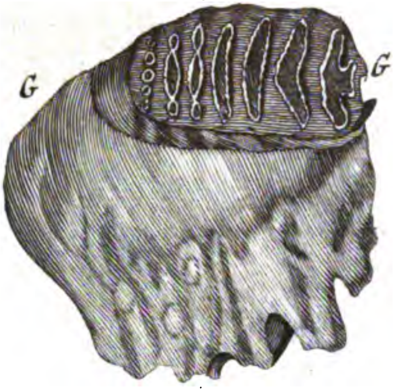


Fig. 26.

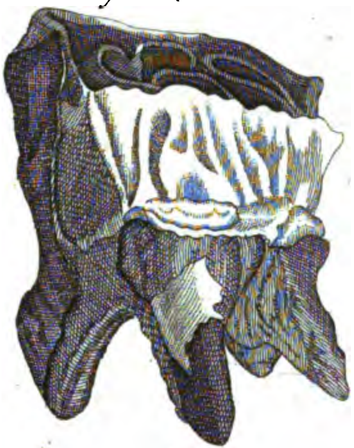
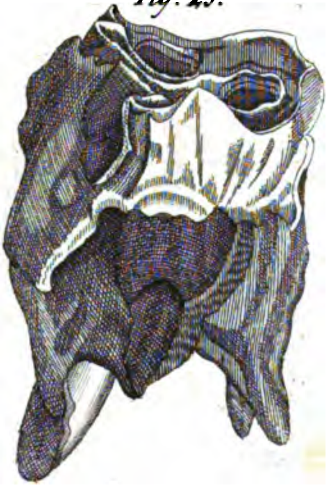


Fig. 27.



33 Feet Diameter; whereas the former is not fully 18. Theſe as they ſunk fell acroſs, ſo that obſtructing each other, only the Root of one of them reaches the Bottom, whereas the firſt ſtands perpendicular.

When the firſt Tree ſunk, it was obſerved that the Water boil'd up in the Hole; but upon the ſinking of the greater Pit, that Water drain'd off into it, from the former, which now continues dry. The depth thereof to the firm Bottom is nine Feet three Inches; and the Tree that ſtands upright in it is three Feet eight Inches in Girt, and its Trunk about eighteen Feet long, half of which is now within the Pit. In the Bottom of the greater Pit there is a Pool of Water about eight Feet Diameter; whoſe Surface is eleven Feet three Inches below the Ground; and the Trees that are in this Pit are much of the ſame length with the other, but ſomewhat ſmaller, the one being in Girt three Feet five Inches, the other but two Feet nine Inches.

The Soil, on which theſe Trees grew, is gravelly; but the Bottom is a Quick-ſand over a Clay, upon which there are Springs, which feed large Ponds adjoining to Sir *Charles Potts*'s Houſe, at about a Quarter of a Mile from theſe Holes.

The Nature of the Soil ſeems to afford us a reaſonable Conjecture at the Cauſe of this odd Accident: The Springs running over the Clay at the Bottom of a Bed of very minute Sand, ſuch as Quick-ſands uſually are, may reaſonably be ſuppoſed, in many Ages, to have waſh'd away the Sand, and to have thereby excavated a kind of ſubterraneous Lake, over which theſe Trees grew: And the Force of the Winds on their Leaves and Branches, agitating their Roots, may well have looſened the Sand under them, and occaſioned it to fall in, more frequently than elſewhere; whereby in length of Time, the thin Bed of Gravel being only left, it might become unable to ſupport its own Weight, and that of the Trees it bore. That this is not a bare Conjecture, may appear from the boiling up of the Water at firſt in the leſſer Hole, and its ſtanding in the bigger and lower. And if it ſhall be found, that it was a very windy Day, whereon this Accident happen'd, it will much add to the Probability of this Solution.

An Accident not unlike this lately happened in *Fleet-ſtreet*, *London*, by the Defect of the arched Roof of a very deep Common-Sewer. The Earth gradually falling into the Sewer, was carried away by it, ſo as not to obſtruct the Water; and the continual Tremor of the Ground, occaſioned by the conſtant paſſing of Carts and Coaches, by Degrees ſhook down the Earth, ſo as to leave a very great Cavern, the Top whereof at length grew ſo very thin, that one Day a weighty Cart having juſt paſt it, a great ſpace of the Pavement ſunk in, in the middle of the Street, not without hazard to a Coach then driving by.

XVI. 1.] There are Grounds in *Scotland*, which we call *Moſſes*, from whence the Country People dig Turf and Peats. The Surface is cover'd with a Heathy, and (as they call it) Heathery Scurf. Under

Of the Moſſes *in* Scotland, *&c. by the Earl of* Cromertie. n. 330. p. 296.

that Scurf there is a black, moiſt, ſpungy Earth; in ſome Places ſhallower, and in ſome deeper; from 3 or 4 to 7 or 8 Feet deep; and in ſome Places, but not in many, to twice or thrice that Depth. They cut the heathy Scurf with a flat kind of a Spade, which they force Horizontally betwixt the Scurf and the ſpongy Earth, and turn up the Scurf in flat thin Flakes, which they call Turfs. It is over-run with the ſmall Roots of Heath or Heather, and when dried, makes a healthy briſk Fire; but with much Aſhes of a whitiſh, duſkiſh, or reddiſh Colour; always the whiter, as it contains more of the woody Roots.

The black ſpongy Earth, which is under the Turf, they cut out in oblong Squares, with Iron Spades made of that Shape, about 8 or 9 Inches long, and about 4 or 5 Inches broad: And as the Men cut them up, the weaker Men, Women and Children, carry them in ſmall Wheel-barrows, ſcattering them on ſome dry Ground, to be dried by Sun and Wind: Some become harder, ſome ſofter, according to the Nature of the Mould, or Earth; the more ſolid, the better Fire; and they are leſs eſteemed, which are more ſpongy. And when they have cut off one Surface, of 4 or 5 Inches deep, they proceed downward to another, until at laſt they come to the hard Channel, unleſs they be ſtopped by Water; which alſo they ordinarily remove by making a Channel to ſome Deſcent, if they can; and if they cannot, there the Water ſtagnates.

And in ſuch waſted Pits, where Water hinders to cut the ſpongy Earth to the Bottom; the Pits will be filled up again, in a good Number of Years, with new Ground of ſpongy Earth; which in Progreſs of Time, will come to the Conſiſtence of *Peat-Moſs*, as at firſt, and a Scurfy Heath-Turf will at laſt grow on the Top of it.

I have obſerved that Peat-Pits, which have been digged ſince I remember, have grown up again with new Peats; and that ſometimes oftner than once in the ſame Pits; ſome Moſſes growing in ſhorter Time than others. But I have obſerved alſo, that when they dig the Peats to the Channel, and in Places where the Water runs off, and doth not ſtagnate, that the Moſſes did not grow, nor renew there again; which moved me to order my Tenants not to cut the Moſſes to the Channel, nor in very large Openings; but rather in ſmaller Pits, that they may grow again more haſtily: And the Event hath anſwer'd my Deſign. But Sir *Robert Adaire* has told me, That without cutting the Moſſes, in the Method of Pits, but by cutting in fully to the Channel, and by laying the heathy Turf, which is cut off the Top of the Moſs, on the Channel, ſo as to cover the Channel over, that in Progreſs of Time a Moſs would grow there again; but not ſo haſtily as in the Pits.

I never obſerved any of theſe Moſſes, which did not ſtand on Plains: Albeit the heathy or heathery Turf, do over-ſpread the Faces and Declivities of the *Scots* Mountains for the moſt Part: There are many Moſſes which ſtand very high on theſe Hills; ſometimes not very far rom the Top. But the Peat-Moſſes are always in a Plain, though here be Deſcents to them, and Deſcents from them; yet I never obſerved them to ſtand on ſuch a Plain, as the Water might ſtagnate on: And they always have a Deſcent to them, from ſome higher Grounds, whereby Water did deſcend to that Plain; which I take to be the Parent of Peat.

In many of theſe Moſſes, there are found Quantities of Fir and Oak Wood; I never obſerved nor heard of other Woods in them. Theſe are ordinarily found in whole Trees; but the ſmaller Branches are ſeldom found unconſumed: I have ſeen very many, and very great Trees, of both Kinds; but generally ſpeaking, the Oak is always black; the Fir ſometimes whiter, ſometimes redder, as is obſerved in all Fir-Woods: But neither Fir nor Oak are found with any Bark upon them. The Fir is generally as freſh and tough, and as fit for Uſe, as any other old Wood is: Only the Wood of theſe found in Moſſes, has ſo imbibed the Water, that it takes a long Time to dry, and fit it for Uſe, eſpecially the Oak; inſomuch, that when it is put into any ſmall Work, it readily warps and changes its Figure. We never find any of the Oaks ſtanding in the Woods, have that Blackneſs; ſo that I preſume, the Blackneſs accrues from the Water.

There are many Places, where Woods do not now grow; albeit People endeavour to cultivate them; and yet the Moſſes in thoſe Places are well ſtored with this kind of under-ground Timber, both Oak and Fir, but eſpecially Fir; ſuch are *Orkney*, the *Lewes* (which are Iſles) *Cathneſs*, *Tarbartneſs*, and the Coaſt of *Buchan*. But yet it would appear, that there have been Woods of old in theſe Places, or how elſe could they come to theſe Moſſes? For a Proof of which, take the following Account:

In the Year 1651. I being then about 19 Years old, and occaſionally in the Pariſh of *Lochbrun*, paſſing from a Place called *Achadiſcald*, to *Gonnazd*, I went by a very high Hill, which did riſe in a conſtant ſteepneſs from the Sea; only in leſs than half a Mile up from the Sea, there is a Plain about half a Mile round; and from thence the Hill riſes in a conſtant Steepneſs, for more than a Mile in Aſcent. This little Plain was at that Time all covered over with a firm ſtanding Wood, which was ſo very old, that not only the Trees had no green Leaves, but the Bark was totally thrown off; which, the old Countrymen told me, was the univerſal Manner in which Fir-Woods did terminate; and that in 20 or 30 Years after, the Trees would ordinarily caſt themſelves up from the Root; and that they would lie in Heaps, till the People would cut them, and carry them away. They likewiſe ſhew'd me, that the outſide of theſe ſtanding white Trees, and for the Space of one Inch inward, was dead white Timber; but what was within that, was good ſolid Timber, even to the very Pith, and as full of Roſin as it could ſtand in the Wood.

About fifteen Years after, I came the ſame Way, and ſaw not ſo much as a Tree, or Appearance of the Root of any; but in the Place thereof, the whole Bounds, where the Wood had ſtood, was all over a plain green Ground, covered with plain green Moſs. I aſked the Country People, who were with me, what became of the Wood, and who carried it away? They told me, no body was at the Pains to carry it away; but that it being all overturn'd from the Roots by Winds, the Trees did lie ſo thick and ſwarving over one another, that the green Moſs (there, in the *Britiſh* Language called *Fog*) had overgrown the whole Timber; which, they ſaid, was occaſion'd by the Moiſture that came down from the high Hill, which was above it, and did ſtagnate upon that Plain; and they ſaid, none could paſs over it, becauſe the Scurf of the *Fog* would not ſupport them. I would needs try it; and accordingly I fell in to the Arm-Pits, but was immediately pull'd up by them. Before the Year 1699, that whole Piece of Ground was turn'd into a common Moſs; where the Country People are digging Turf and Peats. The Peats, as yet, are not of the beſt, and are ſoft and ſpongy, but grow better and better; and as I am inform'd, it does now afford good Peats.

This Matter of Fact, did diſcover the Generation of Moſſes; and whence it is, that many Moſſes are furniſh'd with ſuch Timber.

Theſe Highland Woods are ordinarily ſtored with other Kind of Timber, as Birch, Alder, Aſh, beſides Shrubs, and Thorns; yet we never find any of thoſe Woods remaining in the Moſſes.

What the Reaſon may be, That the Fir and Oak do not now grow in ſeveral Countries, where they are found ſo plentifully in the Moſſes, *Inquirendum eſt*. I ſhall only add, that in a Moſs near the Town of *Elgin* in *Murray*, though there be no River or Water, that runs into the Moſs, yet three or four Feet in the Moſs, there is a ſort of little Shell-Fiſh, reſembling Oyſters, found numerouſly in the very Body of the Peats, and the Fiſh alive with them; though no ſuch Fiſh be found in any Water near to that Moſs, nor in any adjacent River, nor in the ſtagnating Pits that are in that Moſs; but only in the very Subſtance of the Turf: Some of which were ſent to me from the Place, a little before I came from *Scotland*.

—— *on the* Same, *by Dr.* Hans Sloan. *ibid.* p. 302.

2.] What the *Earl* of *Cromertie* obſerves in the *Moſſes*, &c. in *Scotland*, I have found to be true alſo in the North of *Ireland*. I have been an Eye-witneſs there, that when the Turf-diggers have come to the Bottom, or firm Ground, by having dug out all the Earth proper to make Turf or Peat, and come to the Clay or other Soil, by draining off the Water, that then there have appeared Roots of Fir-Trees, with their Stumps ſtanding a Foot or two ſtraight upright, and their Branches ſpread out on every Side horizontally on that firm Surface; as if it had been formerly the outward Face of the Ground, and Place of their Growth. And I have obſerv'd theſe Roots to be ſometimes ſo near one another, as that their Branches were, as it were, matted, grew over, and gave place to one another, as we every Day ſee in Roots of Trees, where they grow too cloſe. I ſaw once the Body of a Fir-Tree dug up ſo big, as to be judg'd fit for the main Poſt of a Wind-Mill; which was diſcover'd, as many of them (which are not found in digging Turf) are, by the Graſs, which grew over it, being in a very dry Summer of a yellowiſh Colour.

Mr. *de la Pryme* ſent me ſome of the Cones found with this Timber in the great Fens of *Lincolnſhire*, which differed in nothing from thoſe of the *Scotch* Fir, which is plentifully growing in *Scotland* at this Day, and which ſome Years ſince were judged ſo proper by ſome to afford Maſts for the Navy Royal, that ſome Perſons were ſent thither for that Purpoſe. But they were not able to bring about what they intended, by reaſon of the Difficulties in the Roads, by which they were to be conveyed to the Sea; which in *Norway* I have heard is in a great Meaſure effected by the Rivers. *Cæſar*, indeed, in his Commentaries, ſays, that the Sorts of Timber in this Iſland, are the ſame as in *France*, *præter fagum & abietem*, except Beach and Fir. The *Earl* of *Cromertie* is a ſufficient Witneſs of his Miſtake, as to one Sort of theſe Trees, and the Beaches in the *Chiltern* Countries near *London*, prove the ſame, as to the other. For the Uſes of this under-ground Timber, beſides thoſe of other Wood, it is ſplit into Pieces, and being lighted, ſupplies the Uſe of Candles. It is alſo made into Ropes, as may be ſeen in the *Muſæum* of the Royal Society, by a long piece of ſuch Rope, bought by the Honourable *Edward Southwell*, Eſq; in *Newry* Market in *Ireland*. The long ſoaking in Water having render'd the Wood of thoſe Trees fit to be made into Ropes. This ſeems to prove, that as the ſoaking of Hemp, Flax, Aloe Leaves, &c. in Water, diſſolves the pulpy part, and leaves the fibrous fit for making into Threads and Ropes, ſo the long ſoaking of Trees may make in Length of Time the ſame, or an analogous Change in thoſe of Wood and Timber. I have ſeen what I thought had been Pieces of Wood, not only in Clay-pits, but even in Quarries or Stone-pits, in the Blocks of Stone raiſed out of their *Strata*, or Layers; and have been aſſured by Mr. *Bellers*, that he hath ſeen large Pieces of Wood in the Stone-pits in *Glouceſterſhire*; and alſo in *Lancaſhire* there is a Moſs, or Turf-Bog, where the black ſpongy Mould, made uſe of for Peats, ſmells very ſtrong of *Bitumen*, or *Petroleum*; of the Oil of which it yields a very great Quantity by Diſtillation. And the late Sir *Edward Hannes* has told me, that near the Lord *Bleſſington*'s Houſe at *Bleſſington* in *Ireland*, there appeared a Light, where the Horſes trampled with their Feet on a certain Space of ſoft Ground: On my Deſire he procured me ſome of this Mould, which agrees exactly in its dark Colour, Lightneſs, &c. with Peat Earth. And on Examination of this by a Microſcope, I found the Light proceeded from many ſmall half tranſparent whitiſh live Worms, which lay in it.

The Blackneſs of the Oak, comes, in my Opinion, from the vitriolic Juices of the Earth ſoak'd into the Oak, which being aſtringent, is turn'd black by them. Ink is made of Galls, an aſtringent Excreſcence of a ſort of Oak in *Turkey*, made by an Inſect there; and of green Vitriol, which is made of the Pyrites diſſolved by Rain-Water, and Iron. Earth of all Sorts, and even human Calculi, and the Aſhes of Vegetables, have in them Particles of Iron, in greater or leſſer Quantities. The Pyrites is alſo very common. The Particles of Iron coming to be diſſolved by this Pyrites, Subacid, or other Salts diſſolved by Water, or perhaps by Water it ſelf, and carried into theſe Bogs, there faſtens to the Tree, ſoaks into it, and turns it black.

Theſe Particles in ſome River Water, faſtening to the Oak-Timber floated in it, give the ſame a darkiſh Colour, taken Notice of by Mr. *Pepys* in his Naval Memoirs of *England*, p. 71. where we are told by the moſt famous Ship-Builders of *England*, "That the beſt foreign "Plank for the Royal Navy, was brought either from *Dantzick*, "*Quinborow*, (that is *Koningſtberg)* or *Riga*, of the Growth of *Poland* "and *Pruſſia*, or from *Hamburg*; namely, that ſort thereof, which is "ſhipped from thence of the Growth of *Bohemia*, diſtinguiſh'd by its "Colour; as being much more black than the other, and render'd ſo "(as is ſaid) by its long ſobbing in the Water during its Paſſage thither."

In the Turf Bogs of *Ireland* 14 Feet deep, are found not only the Mouſe-Deers Horns, mentioned in one of the *Tranſactions*, but likewiſe their whole Skeletons, wherein the Bones bear the ſame Proportions to the like Bones of other Deer, as the Horns bear to their Horns. There are alſo found therein, Gold Chains, Pieces of Money, and Roots of Heath, ſeveral *muſci*, and Branches of Trees, ſo ſoft, as to give no Reſiſtance to the Turf-Spade: And I was told, that in cutting Turf in one, they at ſeveral Feet deep cut through what the *Iriſh* call a Ruſkin of Butter (which was a Firkin, or Veſſel, made of the Barks of Trees, uſed by the old *Iriſh* for putting up their Butter.) And I remember, that in digging the wet Dock at *Deptford*, there were found at the Bottom, about nine Feet deep, Graſs Leaves, Hazel-Nuts, and Roots of Trees: And there was alſo found a Piece of Money, as they call'd it; which prov'd to be a Leaden Seal to ſome Bull of Pope *Gregory* the IX*th*, who continued Pope from the Year of our Lord 1227, to 1241.

* Vol. V.

From *Leland*, * who wrote in the Reign of King *Henry* VIII. we may learn the common Opinion in his Days, of the Cauſe of the Deſtruction of Woods, the growing of Moſſes and Pools; and that, at that Time, in *Wales*, the Senſe of the Inhabitants was, that the under-growing Trees found there, had formerly grown there.

“In theſe Deyes in *Mone* where they digge Turves be founde greate Rootes of Trees that ſerve Men for Wood. For after the Trees wer cut doune ſogging Yerth and Moſſe overcoverid them, and now the ſame Yerth parid away for Turves, the old mayne Rootes appere. Leland's *Itinerary, Vol.* V. p. 13.

“Likewiſe at low Water about al the ſhores of both Shores of *Aberdein* and *Towen Merioneth* appere like Rootes of Trees.

“I ſaw hard by on the lift Honde a great Fenny More, owt of wich the Inhabitantes therabout digge Turfs for Fier, and by the ſame Fenne is a fair *LLin*, cawllid *LLinridde* ii Miles from *Strateflur*. p. 67.

“*Strateflure* is ſet round about with Montanes not far diſtant, except on the Weſt Parte, wher *Diffrin Tyve* is. Many Hilles therabout hath bene well woddid, as evidently by old Rotes apperith, but now in them is almoſt no Woode. p. 68.

“The Cauſſes be theſe; Firſt the Wood cutt doun was never copiſid, and this hath beene a great Cauſe of Deſtruction of Wood thorough *Wales*. Secondly after cutting doun of Woddys the Gottys hath ſo bytten the young Spring that it never grew but like Shrubbes. Thirddely Men for the nonys deſtroied the great Woddis that thei ſhould not harborow Theves.

“From *Whitchurch* a Mile and a half of I cam by the Pale of the large Parke of *Blakmer* longging to the Erle of *Shreuſbiri*, wherein is a very fair Place or Loge. The Park hath both redde Dere and falow. In the Parke (as I hard ſay) be iii. faire Poles, of the wich I ſaw by the Pale the largeſt called *Blakein*, whereof the Park is namid. p. 75.

“It is to be ſuppoſid that thes Pooles for the moſt part in Moriſch Groundes, and lying ſumwhat in low Groundes, dreane the moiſt Places about them, and ſo having no Place to iſſue owt ſtagne there.

“Sum be likelyhod have begon of Marle Pittes. For the Sandy Grounde of ſum Parts of *Shropſhire*, and eſpecially of *Cheſtreſhire* and *Lancaſtreſhire*, will not bere Corne plentifully but it be merlyd.

“From *Blakemers* to *Byklem* in a Foſſe iii. Miles of Sand hard by *Cholmeley*, firſt I ſaw the great Numbre of Firre-Trees, the wiche the Inhabitants thereby communely digge up for Fier Wood, but there did I ſe no Fyrre-Trees grouing. Oftentimes in diggin in this Moſſe or More for Petes or Turves they finde the hole Trees of the firſt, ſum ſhort and ſum veri long, without Twike or Bow, lying ſumtime not a Foote, ſumtime iii. or iiii. Foote depe in the Grounde, but how or when thes Trees cam doune ether be cutting or Wind Faulle no Manne ther can telle. The Wood of them in Burning ſavorith of Reſine.

“*Morle* (in *Darbyſhire*) Mr. *Lelandes* Place is buildid ſaving the Fundation of Stone ſquarid that riſith within a great Moote a vi. Foote above the Water, all of Tymbre after the commune ſort of building of Houſes of the Gentilmen for moſt of *Lancaſtreſhire*. There is as much Pleaſur of Orchardes of great Varite of Frute and fair made Walkes and Gardines as ther is in any Place of *Lancaſtreſhire*. He p. 79.

" brennith al Turfes and Petes for the Commoditie of Moſſes and " Mores at hand. For *Chateley* Moſſe that with breking up of A- " bundance of Water yn hid did much hurt to Landes thereabout, and " Rivers with wandring Moſſe and corrupte Water, is within leſs than " a Mile of *Morle*. And yet by *Morle* as in Hegge Rowes and Grovettes " is meately good Plenti of Wood, but good Huſbandes keep hit for " a Jewell.

" Syr *John Holcroftes* Houſe within a Mile or more of *Morle* ſtood in " jeopardi with fleting of the Moſſe.

" Riding a Mile and more beyond *Morle* I ſaw on the right hond a " Place nere by of Mr. *Adderton*, and ſo a ii. Miles of to *Lidiate Moſſe*, " in the right ſide wherof my Gide ſaid that ther were Rootes of Fyrre " Wood.

p. 81. " Al *Aunderneſſe* for the moſt parte in time paſt hath been ful of Wood, " and many of the Moores repleniſhid with hy Fyrre Trees.

Obſervations on the Strata *in* Coal-Mines, *&c. by* J. Strachey, *Eſq*; n. 360. p. 968. Fig. 37.

XVII. I have made ſome Obſervations relating to the different *Strata* of Earths and Minerals found in the Coal-Mines of *Mendip* in *Somerſetſhire*. The Draught (*Fig*. 37.) you muſt ſuppoſe the Section of a Coal Country, and to take in about four Miles from the North-Weſt, to the South-Eaſt, and may be applied to the Veins of Coal, as they lie at *Faringdon Gourney*, and likewiſe at *Biſhop-Sutton*, which laſt Place is near *Stowy*, but in the Pariſh of *Chew-Magna* in *Somerſetſhire*. For Diſcovery of Coal they firſt ſearch for the *Crop*, which is really Coal, though very friable and weak, and ſometimes appears to the Day, as they term it, or elſe for the *Cliff*, which is dark or blackiſh Rock, and always keeps its regular Courſe as the Coal does, lying obliquely over it: For all Coal lies ſhelving like the Tyle of a Houſe, not Perpendicular nor Horizontal, unleſs it be broken by a Ridge, which is a parting of Clay, Stone or Rubble; as if the Veins by ſome violent Shock were disjointed and broken, ſo as to let in Rubble, *&c.* between them. The Obliquity or *Pitch*, as they term it, in all the Works hereabout, is about 22 Inches in a Fathom; and when it riſeth to the Land, is called the *Crop*, but in the North *Baſſeting*. In the Works near *Stowy*, and likewiſe at *Faringdon*, it riſeth to the North-Weſt, and pitcheth to the South-Eaſt; but the farther they work to the South-Weſt, the *Pitch* inclines to the South; and *è contra*, when they work towards the North-Eaſt. So likewiſe they obſerve, as they work to the South-Weſt, when they meet with a *Ridge*, it cauſeth the Coal to trap *up*; that is, being cut off by the *Ridge*, they find it over their Heads when they are through a *Ridge*: But on the contrary, when they work through a Ridge to the North-Eaſt, they ſay it *traps down*, that is, they find it under their Feet.

Coal is generally dug in Valleys or low Grounds. The Surface in theſe Parts is moſtly a red Soil, which under the firſt or ſecond Spitt degenerates into *Malm* or *Loom*, and often yields a Rock of Reddiſh

Fireſtone, till you come to four, five, and many Times to twelve or fourteen Fathom depth, when by Degrees it changeth to a grey, then to a dark or blackiſh Rock, which they call the *Coal Clives*. Theſe always lie ſhelving and regular as the Coal doth. But in theſe Parts they never meet with *Fireſtone* over the Coal, as at *Newcaſtle* and in *Staffordſhire*. Theſe *Clives* vary much in Hardneſs, in ſome Places being little harder than *Malm* or *Loom*, in others ſo hard as that they are forced to ſplit them with Gun-powder: So likewiſe in Colour, the Top inclining to red or grey, but the nearer to Coal the blacker they grow; and whereſoever they meet with them they are ſure to find Coal under them. But to their Diſappointment 'tis not always worth the digging. The firſt or uppermoſt Vein at *Sutton* is called the *Stinking Vein*. It is hard Coal, fit for mechanick Uſes, but of a ſulphurous Smell. About five Fathom and half, ſeldom more than ſeven Fathom, under this lies another Vein, which from certain Lumps of Stone mix'd with it like a *Caput mortuum*, not inflammable, called *Cats-head*, they call the *Cathead Vein*. About the ſame Depth under this again lies the *Three Coal Vein*, ſo called becauſe it's divided into three different Coals; between the firſt and ſecond Coal is a Stone of a Foot, in ſome Places two Feet thick; but the middle and third Coal ſeem placed looſe on each other, without any Separation of a different Matter. Theſe three Veins before-mentioned are ſometimes work'd in the ſame Pit: But the next Vein which I am going to mention, is generally wrought in a ſeparate Pit; for though it lies the like Depth under the other, the *Cliff* between them is hard and ſubject to Water; wherefore I have repreſented a Pit ſunk through the three upper Veins at *A*, and another ſunk upon the *three Coal Veins* only at *B*; and ſo if they ſink on any of the lower Veins they go more to the North-Weſt. Fig. 37.

Next under the *three Coal Veins* is the *Peaw Vein*, ſo denominated becauſe the Coal is figured with Eyes reſembling a Peacock's Tail, gilt with Gold, which Bird in this Country Dialect is called a *Peaw*. The *Cliff* alſo over this Vein is variegated with *Cockle-ſhells* and *Fern-Branches*, and this is always an Indication of this Vein, which, as I before hinted, is always ſearched for about 15 Fathom to the North-Weſt of the former.

Under this again, between five and ſix Fathom lies the *Smith's Coal Vein*, about a Yard thick; and near the ſame Depth under that again, the *Shelley-Vein*: And under that a Vein of 10 Inches thick, which being little valued, has not been wrought to any Purpoſe.

Some ſay there is alſo another under the laſt, but that has not been proved within the Memory of Man. At *Faringdon* they have the ſame Veins, which, as I am informed, agree in all Parts with thoſe of *Biſhop-Sutton* before-mentioned. But as *Faringdon* lies four Miles South-Eaſt from *Biſhop-Sutton*, ſo, in the regular Courſe, they would lie a Mile and a half deeper than thoſe at *Sutton*. But as in Fact they are dug near the ſame Depth, it follows there muſt be a *Trap*, or ſeveral *Traps down*, which in all muſt amount to that Depth between the ſaid Works.

Between *Faringdon* and *High Littleton* the ſame Veins ſeem to retain their regular Courſe; but at *Littleton* their undermoſt and deepeſt Vein is the beſt Coal, which at *Faringdon* proves ſmall.

On the other hand, in the Pariſh of *Stanton-Drew*, to the North-Eaſt of the Coal-works at *Sutton* aforeſaid, about a Mile diſtant, and in the true Courſe with thoſe at *Sutton*, the ſame Veins are found again. But here they wind a little, and their Courſe or Drift runs almoſt North, and they dip to the Eaſt; which Winding is attributed to *Ridges*, which the Workmen have met with on both Sides, and have occaſioned them to diſcontinue the Work that way. At *Stanton* they have little of the red Earth or *Malm* on the Surface, but come immediately to an *Iron-Gritt* or *grey Tile Stone*, which is a Fore-runner of the *Coal Clives*; in all other Matters they agree with the Works near *Stowy*.

In the ſame Pariſh of *Stanton-Drew*, a little to the Eaſtward, they have another Coal-work, but the Veins are in all Reſpects different from the former. Their Drift or Courſe is to the Eleven a-Clock Sun, as they term it, they *Pitch* to the Five a-Clock Morning, and riſe to land; conſequently to the Five a-Clock Evening Sun. They have ſeveral Veins, but as yet only three are thought worth working. The uppermoſt about three Feet thick ſmall *Lime Coal.* The next is about three Fathom under it, about two Feet and an half thick, fit for culinary Uſes: The undermoſt is about the like Depth under the former, only 10 Inches thick, but good hard Coal.

At *Clutton*, about two Miles from theſe latter, in the ſame Drift, *viz.* almoſt to the South Eaſt and by South, theſe laſt Veins appear again. The Surface here is red, and ſo continues to ten, and ſometimes to fourteen Fathom, and in other Reſpects agree with the laſt mention'd Works at *Stanton-Drew.*

At *Burnet*, *Queen-Charlton*, and *Briſleton*, they have four Veins which pitch to the North nearly, and conſequently the Drift lies almoſt Eaſt and Weſt. The Surface is red Land generally to the Depth of four or five Fathom. The uppermoſt is from three to ſix Feet thick at *Briſleton*, but leſs at *Charleton* and *Burnet.* The next call'd *Pot-Vein*, is ſix Fathom under the former, eighteen Inches thick, all hard Coal. *Thirdly*, The *Trench-Vein*, ſeven Fathom under the other, which is from two Feet and a half to three Feet thick, all ſolid Coal. *Fourthly*, *Rock-Vein*, always diſtinguiſhed by a Rock of Paving-Stone, called *Penant*, lying over it, which Rock is ſometime twenty Feet thick or more, and therefore this Vein is never wrought in the ſame Pit with the former Vein, but about 200 Yards more to the South, or to Land, as they term it. It's computed ſeven Fathom under the former.

This is all I can ſay in Relation to the different Veins of Coal and Earth in the Coal-works in theſe Parts; wherein all agree in the oblique Situation of the Veins; and every Vein hath its *Cliff or Clives* lying over it, in the ſame oblique Manner. All of them pitch or riſe about twenty-two Inches in a Fathom, and almoſt all have the ſame *Strata* of Earth, Malm, and Rock over them, but differ in reſpect to their Courſe or Drift, as alſo in Thickneſs, Goodneſs, and Uſe.

Now as Coal is here generally dug in Valleys, ſo the Hills which interfere between the ſeveral Works abovemention'd, ſeem alſo to obſerve a regular Courſe in the *Strata* of Stone and Earth found in their Bowels. For in theſe Hills (I mean thoſe only that are diſperſed between the Coal-works above-mention'd) we find on the Summits a ſtony Arable mixt with a ſpongy yellowiſh Earth and Clay; under which are Quarries of *Lyas*, in ſeveral Beds, to about 8 or 10 Feet deep, and ſix Feet under that, through yellowiſh *Loom*, there is a blue Clay inclinable to *Marle*, which is about a Yard thick: Under this, is another Yard of whitiſh *Loom*, and then a deep blue Marle, ſoft, fat, and ſoapy, ſix Feet thick; only at about two Feet thick it is parted by a *Marckaſite* about ſix Inches thick.

It is to be obſerved, that theſe Beds of *Stone* and *Marle*, different from *Coal*, lie all horizontal.

Of the Foſſils *of* Reculver *Cliffs, &c. by Mr.* S. Gray. n. 368. p. 762.

XVIII. 1.] About half a Mile from *Reculver* towards *Herm*, there appear in the Cliff *Strata* of Shells in a greeniſh Sand; they ſeem to be firm, and ſome of them are entire, but when you go to take them from their Beds, they crumble to Powder between your Fingers; but that which is moſt remarkable, is, that in the lower Part of the *Strata*, where the Shells are more thickly diſperſed, there lies ſcatter'd up and down Portions of Trunks, Roots, and Branches of Trees; the Wood is become as black as Coal, and ſo rotten, that large Pieces of it are eaſily broken with one's Fingers. I know not what Depth theſe may lie, the *Strata*'s Surface not appearing above two Feet from the Beach, but I judge it from the Superficies of the Top of the Cliff, about 12 Feet. I ſaw the Stump of one Tree ſtanding upright, broken off about a Foot from the Ground. The Shells were of the White *Conchites*.

— *A* Remark *by Dr.* Hans Sloane, *ibid.*

2.] It is very likely, that the Black Wood, mention'd by Mr. *Gray*, is Oak, which has lain ſo long as to be turn'd of that Colour by the vitriolic Juices of the Earth, in which it has lain; as Galls and a Solution of Vitriol turn of that Colour. I never ſaw any Oak that had lain any Time in any Kind of Earth, where Water came to ſoak into it, that was not turned of that Colour: And I have ſeen many Trees of Black Wood of great Bigneſs, taken up (as well as leſſer Pieces) and all of it was Oak. It looks at firſt taking up like Ebony, is very ponderous, but as it dries, it ſplits, grows friable, light, and comes to be good for little.

Some Remarks *on* Foſſils, *by Mr.* E. Lhuyd. n. 291. p. 1566.

XIX. 1.] The State of *Foſſils* is quite different in *Eſſex*, from what it is in *Wales* and *Ireland*. In thoſe Countries the Shells are generally *Cryſtalline*, but in *Eſſex* (and ſometimes about us at *Oxford*) they are *Teſtaceous:* Which Difference is, doubtleſs, to be attributed to the Soil, and particularly to Chalk and Flint, which all thoſe Countries want, excepting a ſmall part (I know not by what Chance of *Diluvian Diſſolution)* got into the *North* part of *Ireland*. But there 'tis remarkable that their Chalk is abſolutely petrify'd: I mean, whereas the Flints are here imbodied in Chalk, they are there in a Chalk-white *Lime-ſtone*. And as chalky Countries only afford thoſe *Echinitæ* I have ſtil'd *Pileatus*, *Galeatus*, and *Cordatus*; ſo I could never find them in all my Travels, but at that Place; from whence, in the Time of *Paganiſm*, the *Druids* procur'd them, and ſold them amongſt our *Northern Britons* for Stones of miraculous Efficacy againſt Perils by Fire and Water; perſuading the Vulgar they were generated in *Cocks Knees*, as Thouſands in the *High-lands* believe at this Day. And one Fellow had the Impudence to tell me (finding me a little hard of Belief) that he himſelf had taken one (that his Maſter had ſhew'd me) out of a Cock's Knee with his own Hand.

We were ſurpriz'd here at *Oxford*, to find ſo many *Foſſils*, ſcarce diſtinguiſhable from *Sea Shells*; the Caſe being uſually otherwiſe in thoſe places I ſearched. We have indeed in theſe Parts, one or two *Foſſil Shells* of a *Teſtaceous* Subſtance, but in Colour they recede farther from thoſe of the Sea, than thoſe in *Eſſex*. I find that thoſe in *Eſſex* are ſometimes found imbedded in ſolid Stone; which takes off any Objection ſome might offer, of their being an accidental ſcattering of *Gulls*, *Crows*, &c. on the *Harwich Cliffs*.

Of Harwich *Cliff, and its* Foſſils, *by Mr.* S. Dale. *ibid.* p. 1568.

2.] *Harwich Cliff* is a ſort of *Promontory*, which divides *Orwel Haven* from the *Æſtuarium* contained between that and *Walton Naſe*; it is ſituate on the ſouthern Part of the Town, about a Quarter of a Mile diſtant, or not ſo much, and contains many Acres of Land. The Height of it from the Strand or Beach to the Top, where it's higheſt, is 40 or 50 Feet. At the Bottom of this Cliff, there is a *Stratum* of Clay about a Foot thick, which is ſucceeded by another of Stone for a Foot more; in this *Stratum* of Stone are imbedded divers Shells (though but thinly) as well of the *Turbinate*, as *Bivalve* Kind, and alſo Pieces of Wood and Sticks; over this, are divers *Strata* of blueiſh Clay, about the Height of twenty Foot, or more; this Clay hath *Pyrites* or *Copperas* Stones, ſticking in it, but no Shells, that I could obſerve: Above this, are likewiſe divers *Strata*, which reach to within about two Feet of the Surface, ſome of which are only of fine Sand, other ſmall Stones and Gravel, mixt with Fragments of Shells, and in others ſmall Pebbles are mixt; and it is in ſome of theſe laſt mentioned *Strata*, that the *Foſſil Shells* are imbedded, which lie promiſcuouſly together, I mean the *Bivalve* or *Turbinate*; neither do the

Strata with the Shells obſerve any Order in their lying, being ſometimes higher, and ſometimes lower in the Cliff; and ſometimes 2 or 3 one above another with other *Strata* of Sand, Fragments, and Gravel, between. Above all theſe, is a Covering of common ſandy Earth, which is about 2 Feet thick, in which, in ſome places are Veins of a Species of *Oſteocolla*, though more tender than *Oſteocolla Officinarum*, which is brought from *Germany:* This I call *Oſteocolla Anglicana*, it doth incruſt about ſmall Strings, like the Fibres of the Roots of Trees, it's of divers Magnitudes, and ſends forth Branches here and there, but is ſo tender, as not to be gotten out of the Earth in any large pieces. Whether like the *German* it appears above the Earth, I never could diſcover.

Before this Cliff, the Shore, as far as the ebbing of the Sea would permit my Obſervation, was rudely paved with Stones, divers of which are vein'd with that ſort of Body, which by *Helmont* and other latter Naturaliſts, is called *Ludus Paracelſi:* Of theſe Stones the Inhabitants have a Tradition, that they are form'd by the Clay, which tumbling down from the Cliff, and being waſhed by the flowing of the Sea, are in a ſhort Time converted into Stone; and Mr. *Silas Taylor* in his Manuſcript *Collections of Harwich and Dovercourt*, (a Copy of which I have) thus writes concerning it. *The Waſhing of theſe* Cliffs *diſcovers a blueiſh Clay, which tumbling down upon the Shore, altho' waſhed by the Sea at High-water, within a ſhort time turns into Stone: There they may be ſeen, ſome that are new fallen, as ſoft as the Clay in the Cliff; and others that have lain there longer, cruſted over and hard, but if opened or broke, the Clay ſtill ſoft in the middle; others that have lain longeſt petrified to the very heart, and with theſe the* Walls *of the* Town *are for the moſt part built, and the* Streets *generally are pitch'd.* How far this is Matter of Fact, I will not determine, my Stay at *Harwich* being alwaws too ſhort for me to make Obſervations ſo critical as this *Phænomenon* doth deſerve; and although I muſt at the ſame time own, that many of the Stones are waſhed out from the *Stratum*, at the Bottom of the Cliff; yet I have ſometimes been inclined to Mr. *Taylor*'s Opinion, becauſe he lived long upon the Spot, being *Store-keeper* of the *King's Building-yard* for many Years, and by his *Collections*, &c. ſeems to be a perſon of probity and Learning; and alſo, becauſe divers of the ſaid Stones have Cracks or Chops in them, as Clay and Earth will have by being expoſed to the Sun; and there is yet [*Anno* 1702,] lying upon that Shore a Stone, in which a large pile (perhaps of Oak) ſuch as was formerly made uſe of there, to preſerve the Cliff from the Injuries of the Sea, doth evidently appear to be imbedded; which can owe its Situation to no other Original, than by being preſt into the Superficies of the Clay, while ſoft, and petrifying with it, which being ſquare, takes off an Objection, which ſome might make, had it been round, of its being lodged there in the general Deluge.

I am not inſenſible, that this Manner of Petrification is not only different from the common Methods Nature uſes in that Operation, but alſo is oppos'd by divers learned and ingenious Men; as particularly by the Reverend Mr. *John Morton* in *Oxendon* in *Northamptonſhire*, whoſe Thoughts upon this Subject I ſhall tranſcribe from a Letter of his, to me, dated *Auguſt* 4, 1699 ——— *At* Harwich, *under the Cliff, upon the Sea-ſhore, there is a* Stratum *of a* Clayey-Stone, *which is cover'd here and there with ragged Stones of a cloſer texture, which was formerly (I conjecture) another entire* Stratum, *but is broken thus by the Tearing of the Waves. The* Clayey-Stone Stratum, *Mr.* Luffkin, *and you, were of opinion, had been formerly a ſofter Subſtance, but was daily petrified by the Sea Water. Having argued a little about it, when turning to the Cliff, I found a* Stratum *there, of the very ſame ſort of* Clayey-Stone, *with that upon the Shore; yet the Sea Water very ſeldom comes up hither, unleſs by Storms, and at Spring-tides. I broke a little piece off, and ſhew'd it to you, and then you was convinc'd (I think) it was not hardned or petrified by the Sea Water, but in its natural ſtate. And I have often met with juſt ſuch ſort of Stone in many of our* Stone-Pits *here, in Inland Countries. It appears to me, that the Water ſhould have rather ſoftned, than hardned the Stone upon the Shore, tho' by waſhing away the looſer Clayey matter and other Earthy ſtuff, that is ſometimes left upon it at the ebb, it might ſeem to be a ſort of* Petrification, *and occaſion this miſtake.*

As to Petrifactions: *I've only obſerved theſe three ſorts.* 1ſt, A Stony Incruſtation, *upon Sticks and any thing that lies in the way, in the Petrifying Springs; the Earth in thoſe Waters is uſually intermixt with particles of Stone, that trickle down into it with the Water, and are there detain'd. Of this firſt ſort you have doubtleſs many inſtances in* Eſſex, *and I think there is one at* Harwich *Cliff; tho' this in my opinion is not ſo properly call'd a* Petrifaction. 2dly, *The ſecond ſort is that, which is perform'd by the* Permeation *or* Inſinuation *of the finer ſorts of Stony* Particles, *as it is in the caſe of ſome of our Petrifying waters, (I believe) particularly that at* Knareſborough *ſometimes; the Stony particles however of the* Knareſborough *Spring are very fine. And many of the* Foſſil-ſhells *have undergone the ſame fate.* 3dly, *The third, which indeed is a* Petrification, *properly ſo call'd, is often met with on the ſides of* Caves *and* Grotto's, *at* Pooly-hole *in the* Peak, *and in the* Fiſſures, *and* Clefts *of* Mines *and* Quarries. *Of this kind are the ſeveral ſorts of* Fluors, the Lap, Stillatitii, Stalagmitæ, &c. *that we meet with in the* Fiſſures, *and* Hiatus's *of the Earth. Theſe are continually growing (as they vulgarly ſay) that is, are receiving an additional increaſe of real and ſolid Stone, as is obſerved in many* Caves *in the* Peak, *&c. This I take to be perform'd in ſuch a manner, as the* Incruſtations *are,* viz. *the particles of Stone are brought along with the Water, as their* Vehicle, *and are depoſited at length upon the ſides of the* Cave *or* Fiſſure, *(this is matter of fact, that there is always a watry Stream, and uſually Water trickling down upon the ſides of thoſe* Caves) *but here, the particles of Stone are extremely minute and fine, and do there-*

by naturally concrete and join together very cloſe; *whereas in our* Incruſtations *the Particles of Stone being groſſer, the Stone is rough and coarſe, and friable. And this I leave to your Judgment, if it be not a more reaſonable* Hypotheſis *than that of Dr.* Plot, *in* pag. 33. *of his* Hiſtory of Oxfordſhire, *viz.* That the very Body of the Water is turned into Stone as it drops down from the Rocks. *I know not indeed of any other ſorts of* Petrification, *than theſe I have already mention'd. As to that* Hypotheſis *of the* Tranſmutation *of a* Stratum, e. gr. *of Chalk to Clay, of Coal to common Stone, or the like, I muſt confeſs I never met with any thing in Nature which would countenance it, that is, ſuch a* Tranſmutation *in the Bowels of the Earth. Nor is there any thing that proves it, that ever I have met with in any* Natural Obſervations. *Only ſome will gueſs and fancy ſuch a Thing*; *but for making it out, I am ſure I am no more able to do it, than to make the* Philoſophers Stone, *whatever they are.*

A late Author is of Opinion, that *this Bed of Stones was the Foundation of the Loamy Cliff, where the Cliff has been waſhed away, or cut: And that they are the Production of a Vitrioline Juice, in Conjunction with the Loam*; as the common Copperas Stones are by the ſame Juice in a *Gravel*, and that the latter were only to be *found* where the *Cliff was gravelly*, and not *where the Loam is.* How far theſe Stones are the Effect of a *Vitrioline Juice*, I will not determine, but this I can affirm, that I have now by me ſome of the *Pyrites*, or common *Copperas Stones*, which I did pick out of the *Clayey Stratum* of this Cliff, in which they may be frequently met with. Nor do I remember at any Time to have obſerved theſe *Stones* to be *inveſted with* either *Gypſum* or *Trichitis*, as the ſame Author affirms, but with the aforeſaid *Ludus Paracelſi*, and ſome other ſorts of *Lap: Stalagmitæ* frequently.

How thoſe Shells or Marine Bodies come to be here poſited, is a Subject, which hath imployed the Heads and Pens of divers learned and ingenious Men. I ſhall not pretend to determine the Controverſy; I ſhall only make ſome Remarks on the poſitive Aſſertion of the aforeſaid Author, concerning the imbedding of theſe *Foſſil Shells* in this Cliff, and the Alteration of the Channel, *viz. That* this *Bed of Shells, which covers the Cliff, was carried thither at the making of the Harbour or clearing of it. For the Harbour or Channel there is artificial, and of no old date, the Current having been formerly on the other ſide of* Landguard-Fort, *which then ſtood in* Eſſex. Againſt the firſt Part of which, altho' many Reaſons might be given to prove the contrary, I ſhall only mention the following; and as our Author begs the Queſtion, *How elſe could the Shells lie a-top* of this Cliff? So I ſhall alſo aſk him, why the ſame *Strata* of Sand, and Fragments of Shells, with the ſame *Foſſils*, imbedded, are to be found at *Walton Neſs*, on the other Side of the *Æſtuarium*, which is 5 or 6 Miles broad from *Harwich*, as likewiſe at *Bawdſey* Cliff in *Suffolk*, which is 8 or 9 Miles diſtant, and in other Cliffs on that Shore, where I have met with them. A ſecond Queſtion may here be aſk'd, How it comes to paſs, that none of thoſe *Buc-*

cinæ Heteroſtrophæ, (whereof ſuch Plenty of their *Exuviæ* are in all the Cliffs hereabouts) are not now to be found in this Channel, nor the adjacent Seas? (where I have divers Times been a Fiſhing) for I cannot think the clearing this Harbour could have deſtroyed all that Species of Shell-Fiſh, whereof there was then ſuch Plenty; and therefore ſome other Original muſt be allow'd them, than what this Author has aſſign'd. Nor can I allow the *Harbour* here to be *Artificial*, becauſe ſo great a Work as this is, *viz.* the making a Channel two Miles wide, as it is in this Place, would not have been without ſome Record thereof in Hiſtory; and beſides the Earth, &c. which muſt ariſe by this Work, muſt conſequently have made a much greater Hill than the Cliff ever was; and another Doubt will from hence ariſe, why the Workmen ſhould bring all the Earth, &c. to this ſide the Channel, and not lay ſome thereof on the other, as it's plain they did not. The Ground on which *Landguard Fort* ſtands, as far as *Walton Coleneſs*, which is about three Miles, is only a ſandy Level or Beach, which I believe hath in Time ſubſided there, as may be obſerved at the Mouths of other great Rivers. And as to the Argument, which our Author brings of *Landguard Fort*, being accounted to ſtand in *Eſſex*, to confirm his Hypotheſis of the Change of this Channel, it will be of no Force with any one, who doth but obſerve, that not only Parts of Pariſhes, but likewiſe of Counties, are often divided from thoſe Pariſhes and Counties to which they belong, and included in others, of which I could give you many Inſtances, *e. gr.* a Part of *Kent* is on the *Eſſex* Side the *Thames*; and in *Oxfordſhire* the Pariſhes of *Shilton* do belong to *Berkſhire*, *Daylesford* to *Warwickſhire*, *Compton* to *Glouceſterſhire*, and *Stratton-Audley* to *Buckinghamſhire*, although all included in the other: And there is a Farm, which doth belong to the Pariſh of *Braintree*, that is ſeparated from it at leaſt two Miles, and many others might be given, but let theſe ſuffice. And to me a probable Reaſon of this Fort's being accounted in *Eſſex*, is, the Sands here ſubſiding, made at firſt, I ſuppoſe, an *Inſula*, which being neareſt to *Eſſex*, was accounted of that County; or 2dly, the Iſland ſo made belonging to none but the Crown, it was at the Pleaſure of the *King's Officers*, to call it of which County they pleaſed. Nor was it *the Gentleman in Cambden*'s Ignorance (whatever this Author ſaith) that made him *mention* theſe Stones *for Petrifactions made by the Sea*; for Mr. *Taylor* in his aforeſaid *Collections* did not omit the Tradition, the Inhabitants of this Town have, about the Alteration of the Mouth of this Haven, which I will tranſcribe in his own Word's. *It's generally believed, that* Stoure *did formerly in a ſtraighter Current (than now it doth) diſcharge itſelf into the Sea, about* Hoaſley-bay, *under the High-land of* Walton-Colneſs *and* Felix-Stow *in the County of* Suffolk, *betwixt which and* Landguard-Fort *are (as they are reputed) certain Remains of the old Channel, which the neighbouring Inhabitants ſtill call* Fleets, *retaining at this Day the Tra-*

dition of the Courſe of the Water, and the Entrance into this Haven to have heretofore been by and through them.

And I am of Opinion that this Tradition is Matter of Fact, having before hinted what Mutations the Mouths of great Rivers daily undergo by the Lodgment of Sands, &c. which may be aſſign'd as a better Reaſon for this Alteration than that of our Author, *i. e.* that it was artificial; and the yearly waſhing of the Cliff on the *Harwich* ſide, doth likewiſe add to its Probability; it being a conſtant Obſervation, that where the Sea gaineth on one Side, it loſeth on the other. And that this Level was ſo made, I am confirmed by the modern Removal of the Fort, more towards the Point; more Sands, I conjecture, being added after the old Fort was built: This Alteration is taken notice of by the aforeſaid Mr. *Tayler* in theſe Words: *And altho' ſeveral now living pretend to the Remembrance of the building it,* [Landguard-Fort]; *yet we find there was an ancienter Fort thereabouts, and called by the ſame Name* [Anno 1553.] *which was not far diſtant from this modern one, a little North of it, where are yet to be ſeen two* Faces *and* Flankers *of a* Baſtion, *the reſt of it being eaten away by the Sea, but in its Place hath left upon the Shore a long row of Sand Banks.*

The Spring mentioned by Mr. *Gibſon* in his *Engliſh* Edition of *Cambden*, from the aforeſaid Manuſcript of Mr. *Silas Tayler*, is a very ſmall inconſiderable Thing; nor could I obſerve that it did petrify or incruſtate either Pieces of Wood or Sticks; but I have a Piece, which I broke off from a large Pile upon that Shore, which was petrified ſo far as it was drove into the Earth, and the Sea-Water came; and do ſuſpect there yet remains ſome others of the ſame. And of this ſort I believe is that large Piece ſent from hence, which Mr. *Tayler* mentions to be *reſerved in the Repoſitory of the Royal Society.*

I have already taken notice, that the *Foſſil Shells* are imbedded in a looſe *Stratum* of Sand, Gravel, &c. which may ſerve to demonſtrate, that their *Matrix* is not a *Clay Bed upon the Top* of the Cliff; as likewiſe for another Argument, to evince, that they could not be there ſcattered by *Crows*, *Gulls*, and other Sea Fowls, as well as that ſome of them are likewiſe bedded in Stone at the Bottom of the Cliff; and although ſome few of them may be met with upon the Top of the Cliff, yet it's only where the Earth has been broken by digging Ditches, &c.

A *Catalogue* of the *Foſſils*, found by me at this *Cliff.*

1. Buccinum foſſile heteroſtrophum roſtratum lævem maximum *Liſteri* referens. 2. Buccinum foſſile roſtratum maximum *Liſteri* referens. 3. Buccinum foſſile minus ventricoſum, mucrone obtuſo. 4. Buccinum foſſile tenue confragoſum. 6. Buccinum foſſile, ſtriis prominulis marginalibus inſignitum. 7. Buccino-turben foſſile reticulatum minus. 8. Buccino-turben foſſile ſulcatum. 9. Buccino-turben foſſile roſtra-

tum. 10. Buccino-turben maximum roſtratum foſſile, ſpiris intus ſtriis elatis inſignitis. 11. Cochlea foſſilis maxima umbilicata quinque ſpirarum. 12. Cochlea foſſilis umbilicata, mucrone obtuſo. 13. Nerita parva foſſilis. 14. Turbo foſſilis, ſpiris duabus ſtriis eminentibus inſignitis. 15. Pecten minor foſſilis unica aurita. 16. Auricularia maxima. 17. Pectunculus foſſilis fere circinatus ſtriis tenuibus, valvis per ginglymon connexis. 18. Pectunculus foſſilis craſſus roſtro acuto ſtriis majoribus. 19. Pectunculus foſſilis faſciis tranſverſis undantibus notatus. 20. Pectunculus vulgaris foſſilis. 21. Pectunculus foſſilis ſtriis majoribus & elatioribus. 22. Pectunculus maximus foſſilis, Liſterianum maximum referens. 23. Pectunculites maximus ſtriis latis. 24. Concha parva foſſilis, faſciis tranſverſis inſignis. 25. Concha longa foſſilis faſciata. 26. Conchites lævis maxima. 27. Conchites parva faſciata. 28. Trigonella minor, ſive vulgatior Anglica *Lithoph. Brit.* 816.

An Account of Land *and* River-Shells, *&c. found under Ground by Mr.* J. Morton. n. 305. p. 2210.

XX. Mr. *Coxe* of *Mears-Aſhby* in *Northamptonſhire* lately diſcover'd ſome *Land* and *River-Shells* under Ground, in a mooriſh Paſture in *Mears-Aſhby* Field, which Place I went afterwards to view.

It is the more remarkable, becauſe *Land* and *River-Shells* are ſo very rarely met with in digging into the Earth, in Compariſon of *Sea Shells*, and the Teeth and Bones of *Marine* Animals, which occur almoſt every where and in all Countries. The Reaſon of which is now no longer a Difficulty, theſe Bodies having been ſhewn to be all Remains of the Univerſal Deluge; and the Marine Shells being more ponderous than thoſe of the Lands and Rivers ſunk, and were lodged deeper in the Earth, and ſo were preſerved by that Means; whereas the latter being left generally upon the Surface, periſh'd, and are at this Day rarely met with.

Cauſing one to dig into the mooriſh Ground above-mentioned, we found a ſmall Number of Snail Shells of various kinds buried there. At about a Foot in depth they lay very thick; and ſinking ſtill downwards, the Number rather encreaſed till we came to the depth of about three Feet. 'Twas troubleſome to ſink deeper on Purpoſe; but we made Trials for a conſiderable Extent of Ground, *viz.* about 250 Feet in length, and 130 in breadth. Beſides, the ſame Shells were caſt up in ſeveral Places, at Diſtance, by Moles. What we principally obſerved in this Search, was, 1. A moiſt mooriſh black Earth, in ſome Places a Foot and a half, in others ſomewhat above two Feet in Thickneſs. The lower half of it is blacker and denſer than the upper half, of a bituminous Nature, and has all the Characters of Peat-Earth. Beſides Shells we found Stalks and Leaves of Graſs, and alſo of many kinds of other Vegetables, repoſited as uſual in like Bituminous Moors in other Parts of this Iſland. 2. White Earth; ſo at firſt we call'd it: But upon cloſer Inſpection it appeared to be little more than Hay half waſted. So deep as we ſunk into it, we found it every where copiouſly interſperſed with Shells.

The finding theſe Shells under Ground, made it very reaſonable to enquire, whether there were any of the like at this Time, living upon the Surface. I diligently ſearch'd this Place, but could not meet with any live ones of any Kind whatever, there.

The Foſſil Shells were ſome the *Exuviæ* of Land-Snails, the reſt of River or Freſh-water Snails: Of the former, there were the three following Kinds: 1. A ſmall *Buccinum*, of five Wreaths, the *Buccinum exiguum quinque anfractuum*, *Tit.* 7. *Liſt. in Tractat. de Cochleis Terreſtr. Angl.* A Kind obſerv'd by Dr. *Liſter* to live in Moſs upon old Garden Walls at *Eſtrope* in *Lincolnſhire*; by my ſelf at the Moſſy Roots of old Trees in many of the *Northamptonſhire* Woods, as alſo amongſt Moſs upon the boggy Sides of ſeveral ſtanding Springs.

2. A *Cochlea* of the compreſſed Kind, but not ſo much compreſſed as ſome of them are. It has ſix Wreaths, and a ſmall circular *Sinus* in the Center. This, if it is not the *Cochlea umbilicata*, &c. N. 79. *Liſt. Hiſt. Conchil. Lib.* 1. has not hitherto been mention'd by any Writer; though common enough in the Woods in *Northamptonſhire*: I found a great Number of them, for the Compaſs of Ground, incloſed in the Earth, than ever I have done in any of the Places where they naturally breed.

3. The *Cochlea citrina*, *Tit.* 3. *Liſt. de Cochl. Terreſt. Ang.* The common ſtrip'd Snail Shell. But moſt of theſe in the Moor are white, of the Colour of the Shells that have been a long Time dead. In ſome I ſaw faint Footſteps of their former Stripes. Moſt of the Shells of this Kind, were lodg'd about four Feet deep.

We met with only two different Kinds of River Shells: 1. A Perewinkle Shell of three Wreaths, generally leſs than the *Buccinum trium Spirar. Tit.* 24. *Liſt. de Cochleis Fluviatil. Ang.* There was a greater Number of theſe buried in the Moor, than of any of the former Kinds.

2. A Perewinkle Shell of five Wreaths, much ſmaller, and more prominent than thoſe of the *Buccinum longum ſex Spirarum*, *Tit.* 21. *Liſt. de Coch. Fluviat.* 'Tis otherwiſe very like that *Buccinum* in the Faſhion of its Wreaths. It has not yet been deſcrib'd by any Author. We find the Kind now living in one of the *Northamptonſhire* Brooks, call'd the *Iſe*.

The mooriſh Ground, wherein theſe Shells were buried, extends from near the Top to very near the Foot of a ſmall Hill. Above the Moor, upon the Top, and at the Brow of the Hill, is a ſandy Soil of a reddiſh Colour. The whole Face of the Moor is plain and even, conformable to the reſt of the Hill not thus moory of the ſame Declination with it, and appears to be in a natural and undiſturbed State, as much ſo as any of the Slades in the neighbouring Fields; excepting that three or four Trenches have been cut through it of late.

'Tis evident, that theſe Shells were left at the Deluge, when thoſe from Sea were alſo repoſited at Land; and not buried ſince by Deterrations from the Ground above: For then the upper parts of the Moor muſt have been cover'd with a reddiſh Sand, ſuch as the Ground is, for the main, compos'd of: But nothing like that appears near the Shells in this Moor. Beſides, here are dug up ſeveral Shells, that in all Likelihood never bred here, but are Inhabitants of a different Soil; particularly the ſtriped Snail-ſhell: For theſe Animals have peculiar Soils, and affect particular Regions.

An Account of the Skeleton *of a large* Animal *impreſs'd in* Stone, *by* Dr. W. Stukeley. n. 360. p. 936.

XXI. At the Reverend Mr. *South's* at *Elſton* near *Newark* in *Nottinghamſhire*, was lately diſcover'd a Skeleton, almoſt entire, of a large Animal (which I have procur'd for the *Repoſitory* of the *Royal Society*) impreſs'd in a very hard Stone; it had lain Time out of Mind, at the ſide of a Well, where it had ſerv'd for a Landing-place to thoſe that drew Water; but upon removal, the under ſide exhibited this unuſual Form.

The Stone itſelf is a blue Clay-ſtone, the ſame as (and undoubtedly came from) the neighbouring Quarries of *Fulbeck*, or thereabouts, upon the Weſtern Cliff of the long Tract of Hills, extending quite through the adjacent County of *Lincoln*.

Fig. 38.

It is a great Pity, that ſo conſiderable a Rarity ſhould be maim'd and imperfect; but where the remaining part of the Stone is, *which* contain'd the upper Part and Continuation of the Skeleton, or that which was the other ſide, and tally'd with it, is utterly unknown. This Skeleton at firſt was taken to be *Human*, which upon View I am perſuaded it cannot be; it ſeems rather to be that of a *Crocodile* or *Porpeſs*. There are ſixteen *Vertebræ* of the Back and Loins, very plain and diſtinct, with their Proceſſes and intermediate Cartilages. Nine whole or partial Ribs of the Left-ſide, the *Os Sacrum*, *Ilium in ſitu*, and two Thigh Bones diſplac'd a little, the Beginnings of the *Tibia* and *Fibula* of the Right Leg; on one Corner there ſeem to be the *Veſtigia* of a Foot, with four of the five Toes, and a little way off, an entire Toe, now left perfect in the Stone: There are no leſs than eleven Joints of the Tail, and the Cartilages between them of a white Colour, diſtinguiſhable from the reſt. We ſhould impoſe upon our Senſes, to queſtion whether theſe be the real Reliques of an Animal; for the very Bones themſelves are now to be ſeen as plainly, as if preſerv'd in an *Egyptian* Mummy; a very little while ago, the Society had a Draught of a Crocodile, though a ſmall one, found after the like Manner, incloſ'd in Stone, from a Quarry in the Mountains of *Upper Germany*. I ſuppoſe the ſame Reaſon accounts for both, and all the reſt of theſe Kinds of Foſſils; and it is an ocular Evidence, and a great Confirmation of what I laid before the *Royal Society*, in a late Diſcourſe, where I hinted at a Solution of ſome obvious and remarkable Phænomena, in the external Face of the Globe, conſequent to its Formation, as ſet forth in the *Moſaic* Account; and of ſome Changes it ſuffer'd at the univerſal *Cataclyſm*, and Proofs of that great *Cataſtrophe* of the Animal and Vegetable World in Plants, Shells, and Parts of living Creatures found in Rocks and Quarries.

It is remarkable, that all the Stone Pits about the Country whence this came, abound with prodigious Quantities of Shells, and the like, and the greateſt Part of the Subſtance of the Stone is a Compoſition of them. There are many Accounts of them in the *Tranſactions*, and this Stone has many Shells of different Kinds in it. Sir *Hans Sloane* has a Fiſh Skeleton, amongſt his immenſe Treaſure of Curioſities, found near this Place, given by the Duke of *Rutland*. If we look upon a Map of the Country, and obſerve the *Lincolnſhire Alps*, how they run fifty Miles North and South, and on the Weſt-ſide are ſteep and rocky, we may ſee the Reaſon why theſe Quarries ſhould be ſo ſtuft with them; for it is juſt to conceive, that upon retiring of the Waters of the Deluge from the Superficies of this Country, into the Eaſtern Seas, theſe heavy Bodies met a full Stop, and were intercepted by this Cliff, which has retained ſuch vaſt Quantities of them ever ſince: Whilſt thoſe which fell upon common Mould are moſtly rotten, and now loſt.

Sir *Iſaac Newton*'s Doctrine of the Attraction of the Particles of Matter, according to the Quantity of its Solidity, Proximity, and Surface; eſpecially that it is infinitely greater in the Point of Contact, upon which depends its Coheſion and all the Varieties of Phyſical Action, will eaſily direct us to a Notion of Petrifaction. We learn how a proper Degree of Heat or Cold, Moiſture, Motion, Reſt and Time, promote this Principle, from the common Experiments of Chryſtallization and Freezing, even before the Fire, and in many chymical Mixtures. Whence we cannot be ignorant of Stone growing in the Quarries gradually, not by any fancied Vegetation, though there is ſomething like it in Corals, but generally by Appoſition of Parts to Parts, as is notorious in the *Fluors* of ſubterraneous Grots and Caverns. So that we have no Reaſon to doubt but what was Clay, Sand, or Earth 3000 Years ago, may now be Stone or Marble, according to the Proportion of Concurrence of ſuch mentioned Cauſes. This will perſuade us, that the now barren and rocky plains of the Countries of *Syria*, *India*, and *Arabia*, are owing to natural Cauſes, as well as an immediate Curſe of God, for the Diſobedience of its ancient Poſſeſſors his peculiar People; becauſe the ſame is obſervable of the famous Countries of *Greece* and *Africa*, warm Regions ſo renowned for Fertility in ancient Authors. Wherefore there may be ſome Likelihood in the Opinion of thoſe who think that in many Ages the whole Face of the Globe may become one great Rock. Dr. *Plott*, in his Natural Hiſtory of *Oxfordſhire*, gives an Account of a *Tumulus*, now a perfect Mount of Stone; and upon St. *Vincent*'s Rock near *Briſtol*, are Fortifications now become ſolid Cliff. I remember, about ſix Years ago, Mr. *Ralph Widdrington*, Brother to the Earl of that Name, ſhew'd me many human Bones taken from whole Skeletons, with *Britiſh* Beads, Chains, Iron

Rings, Braſs Bitts of Bridles, and the like, which were dug up in a Quarry, near the Seat of the Family, at *Blankney*, *Lincolnſhire*; which very probably was plain Mould, when theſe old Corpſes of the *Britons* were interred; and ſince then I ſaw many human Bones and Armour, with *Roman* Coins, *Fibulæ*, *&c.* found in a Stone Pit in the Park at *Hunſtanton*, *Norfolk*; belonging to Sir *Nicholas L'Eſtrange*, in whoſe Cuſtody they now are, which were conjectured to have been buried in Earth after a Battle. From whence we may judge it a vulgar Miſtake, when in the Ruins of the old Caſtles and Walls we admire the Tenacity of the Mortar, and are apt to praiſe our Anceſtors, for an Art which we ſuppoſe now loſt; when doubtleſs the Strength of the Cement is owing to the Length of Time: And in future Ages our modern Buildings may obtain the ſame Judgment.

From all which Inſtances, I infer the ancient State of theſe Cliffs, where this Skeleton was, and Shells are daily found, intimately mixt in the Subſtance of the Stone, to have been formerly of a ſofter Conſiſtence, capable of admitting them into its Bowels, and to have immur'd them as part of itſelf; and that Earth which is now manageable by the Plough, may poſſibly in Time aſſume the ſame Denſity, at leaſt very little below the Surface; for in this very Cliff the upper *Strata* are yet Clay, growing harder as deeper. What Creature this has been, for want of a Natural Hiſtory of Skeletons, we cannot poſitively determine; but generally find the like to be amphibious or marine Animals. Why ſuch, rather than many others, ſhould chance to be thus entombed, may be thought, becauſe they were able, much longer than Terreſtrial Animals, to live in that World of Waters, even till they began to abate and fall away into their deſtin'd Receptacles; ſo that while the Bodies of the reſt ſoon periſhing, were corrupted, and their Bones ſeparated and diſperſed much earlier; this Skeleton, with others of its like, fell entire into the Fiſſures of this Bed of Clay, which has ſince turned into Stone, and made this noble Monument and pregnant Token of that general Inundation.

Of Chryſtal, *&c. by Mr.* R. Thoreſby. n. 277. p. 1071.

XXII. Dr. *J. Cay* preſented me with a *Chryſtal* (and other Natural Curioſities) which he brought from *Milan*: I ſhall give you his Deſcription of it, firſt premiſing his Arguments upon a ſort of *Spar* within a *Flint*. That within the Flint (ſays he) ſeems to differ from the reſt of its Subſtance, and ſomewhat to reſemble *Spar*: Though after all, *Spar* being nothing elſe but a *Chryſtalline* ſort of *Lime-Stone*, it differs not from *Flint* in Reality, but only in Appearance, *i. e.* in the Manner of *Concretion*: Though if the encloſed Matter had in its Nature differed from the reſt of the Stone, the Thing had not been very uncommon; it being uſual enough for Stones (eſpecially thoſe of a Globular or Oval Form) to have Coat upon Coat, and thoſe Coats ſometimes very different one from another, ſome of them ſoft, ſome hard; nay, ſometimes, after a long Space of Time, one of theſe Coats will ſhrink from another, after the Manner of a Kernel, when the Shell grows dry; and then, if the incloſed Subſtance continue ſoft and marly, they call that Stone *Geodes*; but if ſtony, it makes one of thoſe rattling Stones that are known by the Name of the *Ætites* or *Eagle-Stone*.

To confirm what I have advanced, many Inſtances may be brought, that it is no unuſual Thing for Stones to encloſe Subſtances of a very different Nature from themſelves: The *Shells* which I have ſeen in *Suſſex* Marble is one Proof; and the *Stones* found in our *Coal-Pits*, and known among the Workmen by the Name of *Cat-heads*, may ſerve for another; they are found in a particular *Stratum* near the Coal, and encloſe a *Fern*, or ſometimes *Polipody Leaf* in the middle of them; and for that Reaſon being ſtruck with a Hammer very readily break there: I think they are a ſort of *Iron-Stone*, a-kin to that which they call in *Staffordſhire Ballmine*; and Dr. *Liſter*, *Minera ferri Pilæformis*; they have it upon the Weſtern Coaſts near *Whitehaven*, and call it there by the Name of *Cat-ſcamps*: I have ſeen it too upon the *Yorkſhire* Coaſts in *Robin-Hood*'s Bay: It may be called *Lapis Mineræ ferri, Pilæformi ſimilis in cujus Meditullio unum vel plura Filicis folia repræſentantur.* I have Specimens of both Sorts. And as an Inſtance, that *one and the ſame Piece of Rock does not always ſhoot into Stone at one and the ſame Time, but firſt one Part of it, and then another*, and they too not after the ſame regular Manner: I have a Piece of *Rock Chryſtal*, where one may eaſily obſerve the *Modus Concreſcendi*, in the Middle to have differed from that of the outſide; nay ſometimes I have ſeen in the Middle of ſome tranſparent Stones, a ſmall Drop that never would take the ſolid Form of the reſt of the Stone at all.

Iron.

I have received from Dr. *Cay* a Piece of an *Iron Bolt* (two Inches long) found in a *Stone* Quarry, now returned into *Iron Ore* again; this being a Property that Iron has, and no other Metal, as Dr. *Liſter* obſerves in his Journey to *Paris*.

Copper-Ore.

Fig. 46.

I have received from *Sweden* a Piece of *Copper Ore* regularly ſhot into an *Octoedrous* Form: It has eight ſolid Triangles, and conſequently ſix angular Points; and is of the Bigneſs and Figure of the Draught, (*Fig.* 46.) it came from the Copper Groves at *Fallum*, where very many of the ſame Form were then found.

Of the Luminous *Qualities of* Amber, Diamonds, Gum-Lac, *by Dr.* Wall. n. 314. p. 69.

XXIII. I ſhall give an Account of my Obſervations on ſeveral natural ſolid *Noctiluca*'s, not hitherto by any, as I know, taken notice of; (I think I may be well aſſured ſome of the *Phænomena* never were:) and ſhall firſt ſpeak a little concerning the artificial *Phoſphorus*, which is a Subject I have made a great Number of Experiments about, whereby I was naturally led to the following Remarks.

Many Years ago (about the Year 1680.) Mr. *Boyle* communicated to me his Way of making the *Phoſphorus* with Urine; But his Chymiſt, Mr. *Bilgar*, was forc'd to evaporate a prodigious Quantity of Urine, to get a very little of the *Phoſphorus*; which induced me to think for ſome other

Matter, from which more might be made than from Urine: It being then a very hot Summer, I caus'd a Piece of the dry'd Matter in the Fields, where they empty the Houſes of Office, to be digg'd up, in which, when broken in the Dark, a great Number of ſmall Particles of *Phoſphorus* appear'd; but of this could be made little or no *Phoſphorus*, till another Matter was added to it in Diſtillation.

Reflecting on the artificial *Phoſphorus*, I conſidered whether there might not be, *in rerum naturâ*, other natural ones, beſides thoſe that Mr. *Boyle* and ſome others have given an Account of.

Human Urine and Dung do plentifully abound with an *Oleoſum* and common Salt, ſo that I take the *artificial Phoſphorus* to be nothing elſe but that Animal *Oleoſum*, coagulated with the Mineral Acid of Spirit of Salt, which *Coagulum* is preſerved, and not diſſolved in Water, but accended by Air.

Theſe Conſiderations made me conjecture that *Amber* (which I take to be a Mineral *Oleoſum* coagulated with a Mineral Volatile Acid) might be a natural *Phoſphorus*, ſo I fell to make many Experiments upon it; and at laſt found, that by gently rubbing a well poliſh'd Piece of Amber with my Hand in the Dark, which was the Head of my Cane, it produced a Light; whereupon I got a pretty large Piece of Amber, which I cauſed to be made long and taper, and drawing it gently through my Hand, being very dry, it afforded a conſiderable Light. I then uſed many kinds of ſoft Animal Subſtances, and found none did ſo well as that of Wool. And now new *Phænomena* offered themſelves; for upon drawing the Piece of Amber ſwifty thro' the Woollen Cloth, and ſqueezing it pretty hard with my Hand, a prodigious Number of little Cracklings were heard, and every one of thoſe produced a little Flaſh of Light, but when the Amber was drawn gently and ſlightly through the Cloth, it produced a Light, but no Crackling; but by holding one's Finger at a little Diſtance from the Amber, a large Crackling is produced, with a great Flaſh of Light ſucceeding it, and, what to me is very ſurprizing, upon its Eruption it ſtrikes the Finger very ſenſibly, whereſoever apply'd, with a Puſh or Puff like Wind. The Crackling is full as loud as that of Charcoal on Fire; nay, five or ſix Cracklings, or more, according to the Quickneſs of placing the Finger, have been produced from one ſingle Friction, Light always ſucceeding each of them. Now I make no Queſtion, but upon uſing a longer and larger Piece of Amber, both the Cracklings and Light would be much greater, becauſe I never yet found any Crackling from the Head of my Cane, although 'tis a pretty large one; and it ſeems, in ſome Degree, to repreſent Thunder and Lightning; but what to me is more ſtrange, is, that though upon Friction with Wool in the Day-Time, the Cracklings ſeem to be full as many, and as large, yet by all the Trials I have made, very little Light appears, though in the darkeſt Room; and the beſt Time of making theſe Experiments, is when the

Sun is 18 Degrees below the Horizon; and when the Sun is ſo, though the Moon ſhines never ſo bright, the Light is the ſame as in the darkeſt Room, which makes me chuſe to call it a *Noctiluca*.

As the artificial *Phoſphorus* led me to that of Amber, ſo Amber directed me to that of a *Diamond*, from its being Electral as well as the other; which is alſo a Natural *Phoſphorus*, or rather a *Noctiluca*, exceeding all others, and may, without any Exception, be called a Mineral *Phoſphorus*, it being, as I think, the moſt pure of all *Oleoſums*, coagulated with a Mineral *Acidum*; and if in the Diſcovery of this I have not obliged the Learned, I am in Hopes I ſhall all thoſe who deal in Diamonds: Mr. *Boyle* has given the World an Account, at the latter End of his Book of *Colours*, of Mr. *Clayton*'s Diamond, and afterwards ſays, that ſome Diamonds would not ſhine in the Dark: but if any one elſe has ſince then made a Diſcovery, that all Diamonds would give Light in the Dark, they have been very unkind to the World in not letting them know it, becauſe I am well aſſured that a great many People have been but too often cheated with them, which I hope to prevent. I have now by me a yellow Diamond, which I have ſhewn to a great many Jewellers and others, and but a few of them will allow it to be a Diamond; but by as many Trials as I have made, I think my Way of diſtinguiſhing Diamonds is ſo certain, that none need fear to affirm them to be ſo.

A Diamond, by an eaſy ſlight Friction in the Dark, with any ſoft animal Subſtance, as the Finger, Woollen, Silk, *&c.* appears in its whole Body to be Luminous; nay, if you keep rubbing for a little while, and then expoſe it to the Eye, 'twill remain ſo for ſome little Time: But if the Sun be 18 Degrees below the Horizon, if any one holds up a Piece of Bays or Flannel ſtretch'd tight between both Hands, at ſome Diſtance from the Eye, and another rubs the Bays or Flannel with a Diamond ſwiftly and pretty hard on the other ſide of it, the Light to the Eye of him that holds it, ſeems much more pleaſant and perfect, than any other Way I have yet try'd. But what to me ſeems more ſurpriſing is, that a Diamond being expos'd to the open Air, in View of the Sky, gives almoſt the ſame Light of itſelf without rubbing, as if rubb'd in a dark Room; and if in the open Air you put your Hand or any Thing elſe a little over it, to hinder its Communication with the Sky, it gives no Light: I have try'd all or moſt of the precious Stones, but could find no ſuch *Phænomenon* in any of them. All theſe Experiment were made at the latter End of *May*, and Beginning of *June*, and therefore, I cannot pretend to account for the *Phænomena* that may attend Experiments made while the Sun is on the other Side of the *Equator*.

I am well aſſur'd, that all or moſt of the Bodies which have an Electricity yield Light; for in my Opinion 'tis the Light that is in them, which is the Cauſe of their being Electral; yet this Electricity never ſhews itſelf without Friction; if you rub any Body that has an Electricity,

city, and apply it near to ſome light Bodies, as particularly very thin Slices of Cork, 'twill put them into a great Agitation, and make them ſeem to the Eye, as hanging at the Body by a fine Hair.

I forbear ſpeaking of *Jet*, which ſeems to me to be a black Amber, having moſt of the Properties of Amber, but not ſo perfect and pure.

I muſt not forget to ſpeak of another Subſtance, not hitherto by any (as I know) taken Notice of to be endu'd with a luminous Quality, which is alſo another natural *Phoſphorus* or *Noctiluca*, and that is *Gum Lac*, and alſo red Sealing-Wax, which is made with *Gum Lac* and *Cinnabar*, the *Cinnabar* no Way impeding, but rather promoting its luminous Quality; for I cauſed long taper Rolls to be made up of *Lac* alone, and of pure red Sealing-Wax, both being well poliſh'd: The Sealing-Wax upon Friction, ſeems to me to emit its Crackling and Light ſooner than the *Lac*, which I impute to the *Cinnabar*'s conſtringing its Parts, tho' I think *Lac*, *per ſe*, has the greateſt Electricity, both having all or moſt of the Properties of Amber; and by all the Tryals I have hitherto made of *Lac* and Sealing-Wax, I find that though the Cracklings are as plentiful in the Day-time, as when the Sun is down, yet in the darkeſt Places I could diſcover but a little Appearance of Light, ſo that this deſerves the Name of a *Noctiluca* or *Phoſphorus*, as well as the others; it being no other than a vegetable *Oleoſum*, coagulated with an Animal Volatile *Acidum*. I don't know in the Animal Kingdom any Thing but Piſmires, that affords a Volatile Acid, and in the *Eaſt-Indies* there's a large kind of them that live on the Sap of certain Plants, affording both a Gum and a Colour, which Sap paſſing through the Body of thoſe Inſects or Animals, is by their Acid Spirit converted into an Animal Nature; which is the Reaſon, that with the Colour extracted from *Gum-Lac* (which *Gum-Lac* is nothing elſe but the Excrements of theſe Inſects or Animals) almoſt as good, and full as laſting, Colours are made as from *Cochineal*: I am the more confirmed herein, becauſe I know of an Artificial Way of converting Vegetable Colours into an Animal Nature very much like this, by which the Colours are made more pleaſant and permanent. After the ſame Manner the remaining Gum, which is an *Oleoſum*, being digeſted and paſſing through the Bodies of thoſe Inſects or Animals, is by their Volatile Acid converted into a Vegetable Animal *Phoſphorus* or *Noctiluca*; the Artificial *Phoſphorus* is a Mineral Animal *Phoſphorus*, whereas I take the others to be altogether Mineral.

A Treatiſe on Ambergreaſe, by *G. J. Camelli*, n. 290. p. 1591.

XXIV. According to *Avicenna*, *Ambergreaſe* is generated in the Manner of a Fungus upon Rocks and Trees in the Bottom of the Sea. Others again will have it, that Funguſes grow upon the Surface of the Sea, in the ſame Manner as they grow upon the Surface of the Earth. *Hieronymus à Huerta*, in his Notes upon a Tranſlation of *Pliny* aſſerts, that there are certain Sea-Weeds or excrementitious Maſſes upon the Surface of the Sea, formed like a kind of Fungus, which have no Smell when they are firſt gathered, nor do they become fragrant till they are prepared: And that it is not a *Bitumen*, nor the Seed of the

Whale, becauſe theſe when once hardened, cannot be rendered ſoft again like the *true Ambergreaſe*. *Jonatius Alzina* in his Hiſtory of *Biſai*, ſays it is called by the *Indians Teſa Bonganſiſo*, that is, the Excrement of the Whale, becauſe it is ſometimes found in the Whale; and ſometimes vomited up by it. And he imagines that it is produced from Sea Weed, reſinous Sea Plants, the Reſin of Trees growing in the Bottom of the Sea, or even from rotten Sea Weed, or what they call Sea Ware, ſwallowed by the Whale and digeſted into a kind of Mucilage. *Nicolaus Monardes* will have it to be a kind of Bitumen flowing from Fountains in the Bottom of the Sea; and *Guilli du Wallig.* is of the ſame Opinion. *Simon Sethi* and others ſay that it ſprings up in different Places, and that there are Fountains of it as of Bitumen. *Garcias ob Orta* is of Opinion that probably there are Iſlands or Countries where Ambergreaſe may be found. *Ferdinand Lopez Caſtanneda* will have it to be the Dung of Birds of the Iſland *Maldiva*, which feed upon odoriferous Herbs. *Servatius Marel* told *Carol. Cluſius* that it was produced from a viſcid Matter found in the Stomach of the true Whale. Others again alledge, that it is ſwallowed by the Fiſh called *Azelum*, and taken out near its Back-bone. *Ferdinand Caſtrillo* ſays it is a Liquor collected about the Oeſophagus of Fiſhes, as ſome who are return'd from *Braſil* teſtify. *Fran. Combes* ſays that the Inhabitants of *Iolo* will have it to be the Excrement of the Fiſh *Gudiamina*, which is different from the Whale, and larger. [*] Some ſay that it is produced from an odoriferous Fruit ſwallowed by the Whale. Some call it the Seed, ſome the Liver, ſome with the *Chineſe* (who call it *Hay ano ſay*, that is, preſerving Cloaths from the Moth) the Excrement of the Whale; while ſome again will have it to be a Foam of the Sea. *Cteſias* ſays it is the Seed of the Elephant. *Fuchſius* calls it a Compoſition of Aloes Wood, Civet, Storax and Ladanum. The *Lutai Indians* according to *Combes* ſay, that it is produced from maſſy or viſcid Excreſcencies ſticking to a large Aromatick Tree in the Sea. Others, and thoſe of better Senſe, again alledge, that it is produced from the Reſin of that Tree, and this Opinion the Author himſelf goes into, adding that the crude Ambergreaſe is void of all Flavour, ſo like the Reſin of the *Pilis* (of the Almond and Piſtach Kind) and ſo eaſily inflammable, that many have been deceived by it, and ſuffered for their Heedleſſneſs. *Hieronimus à Huerta* ſays it is the Opinion of ſome, that Ambergreaſe is the Reſin or Gum of Trees, or the Reſin of the Pine-tree. *Thomas Bartholin* in the Medico-philoſophical Tranſactions of *Copenhagen* of the Year 1673, Obſ. 122. f. 306. [†] affirms that it has the ſame Origin with Amber, (*viz.* after he had proved Amber to be the Reſin of Trees) and makes no doubt but that there are odoriferous Trees in *America* which pour out Juices of the ſame Nature. *Tacitus* writes, that as the Trees in the Eaſt ſweat *Thus* and *Balſams* (and why not alſo *Ambergreaſe?*) ſo it was poſſible that thoſe of the Weſt might ſweat Amber. All theſe Opinions and Conjectures being conſidered, is it not moſt probable that its Origin is derived from Trees? For that it is produced in the Manner of Funguſes is extremely doubtful; and that it is derived originally from Sea Weed, or a putrid Recrement of the Sea, I cannot eaſily believe. Neither is it probable that it is a Bitumen, or kind of Earth; and that it is made by Art, is falſe. That it is the Dung of Birds, the Seed of the Elephant, or of the Whale, or a Liquor, the Liver, Seed, or Excrement of ſome other Fiſh, appears to be fabulous. I ſhall willingly grant, however, that ſometimes *Ambergreaſe* being unfit for Nutrition (as *Odoardus Barboſa* remarks) has been vomited up by Whales, or other Fiſhes of the Whale Kind, or has been found in their Oeſophagus, or ſometimes in their Stomachs, theſe Monſters devouring whatever comes in their Way. I very much ſuſpect too, begging Pardon of thoſe who are of the contrary Opinion, that that reſinous Fluid, which the *Indians* of different Provinces call *Agacabac*, *Hagabac*, *Bintege*, *Bintoco*, *Apitono* and *Malibabo*, *Cayancang* and *Bolotic*, and which is the very ſame with that dry and hard Reſin, which was brought to me in large Lumps from the Mountains of *Ilocos* and *Paynan*, is not the true *Ambergreaſe*. But after a violent Storm, and heavy continued Rain, overflowing the whole Country, it is hurried down into the Sea by the Impetuoſity of the Torrent, from the uninhabited inland Parts, and inacceſſible Tops of the Mountains, and being waſhed and toſſed about violently by the Waves, and ſomewhat cleared and ſoftened, by means of the Salt Water and the Force of the Sun's Rays, it is worked up and prepared in the Form that we find it, * from a Reſin either lately waſhed from the Trees, or hardened by lying ſome Time upon the Mountains; and is more or leſs pure, as it has been macerated a longer or ſhorter while as the Sea Water has been more or leſs toſſed, and expoſed to the Sun. But ſuch weighty Bodies are ſeldom thrown out upon the Shore, except after the Country has been overflowed with continued Rains, and the Sea ſtrongly agitated with furious Tempeſts. Thoſe large, ſolid, and pure Pieces of *Ambergreaſe*, free of heterogeneous Bodies, gathered upon the Shore at *Palagpag*, and brought to *Manilla* in *January* 1694, afford a ſtrong and evident Argument for this Conjecture. (Note, towards the End of *February* 1693 there was a violent Tempeſt.) They were *partly* of the Colour of *yellow Amber*, or that of *Gum Arabick*; more duſky than the Reſin ſent from *Ilocos*, which was almoſt as pellucid as Cryſtal, and very like the Reſin which was brought from *Paynan*, but leſs odorous when they were burnt, eaſily melting in the Fire, in the ſame manner as the Reſin, and almoſt of a ſtony Hardneſs, ſo that neither the Knife nor the Teeth could make any Impreſſion upon them. *Partly*, or on one Side, of a whitiſh gray Colour, variouſly cracked, and brittle indeed, but more ſolid than any *Ambergreaſe* I have ever ſeen.

---

[*] *Joes Leon.* in his *Deſcription of Africa* ſays that Ambergreaſe is thrown up by the Fiſh *Ambara*.

[†] *Odoardus Barboſa* remarks the ſame.

---

* *Barboſa* ſays, that by being continually expoſed to the Sun and Moon, it becomes reſinous.

They were ſold however for genuine and the beſt Kind of *Ambergreaſe*. A certain Perſon made a Objection to this Opinion of mine, ſaying that *Ambergreaſe* could not be the Reſin of Trees, becauſe if was found in ſuch large Lumps; to which I anſwered, that the various little Lumps of Reſin of which theſe large ones are compoſed, being homogeneous and adheſive, and drove againſt one another by the Force of the Waves or Torrent, might unite and cohere firmly together ſo as to form larger Pieces. And why ſhould it be impoſſible for large Pieces of this Reſin to be found, when theſe Mountains nouriſh reſinous Trees of an incredible Height, and at *Pilis* and *Lauvan* there are found Blocks of Reſin of a hundred Feet long, and thoſe Fragments that were brought from *Ilocos* and *Paynan* plainly ſhew that the Stock they were taken from muſt have been very large. *Fran. Combes* in his Hiſtory of the Iſlands of *Mindanai*, f. 15. ſays that upon the Shore *Iolò* (called by the *Dutch Date Iſland*) there was found a Piece of Ambergreaſe larger than the Body of an Ox, but it was almoſt all ſold for common Reſin. *Franc. Colin* ſeems to mean the ſame, in his Hiſtory of the *Philippine Iſlands* f. 49. when he ſays that in the Iſland *Iolò* there was found a Piece of *Ambergreaſe* of a gray Colour, and of the very beſt Kind, weighing upwards of two hundred Pounds. And I imagine *Ignatius Alzina* in his Hiſtory of the *Byſaian Iſlands* means alſo the ſame, where he tells of a Piece of Ambergreaſe found at *Iolò*, thicker than a Man's Body, and twice as long, which on Account of its great Plenty was ſold very cheap. In the Year 1632, at the Cape of the *Holy-Ghoſt*, upon the Coaſt of *Igbàbao*, there was found a Fragment of *Ambergreaſe* weighing about five and fifty Pounds, which being extremely good, was ſold for a thirty Imperial Crowns the Ounce. For an *Indian* who found it accidentally, had filled three Baſkets with it, two of which, not knowing what it was, and conſequently ignorant of the Value of it, he had carried Home to burn inſtead of Reſin (for formerly the *Byſaians* for the moſt Part made this Uſe of the *Ambergreaſe*, not diſtinguiſhing it from Reſin) and was going to do the ſame with the third, if a Gueſt he had in his Houſe, who knew a little more of the Affair, had not diſcovered by the Fragrance of the Smoak, that it was not common Reſin, but exceeding fine *Ambergreaſe*. † In *Bangabun*, an old Woman gathering of Shell Fiſh, found a Piece of *Ambergreaſe* of the Bigneſs of one's Arm, which ſhe took to be common odoriferous Reſin, (for there are a great many different Kinds of odoriferous Reſins thrown out upon the Shore, as *Batete*, which ſmells like *Ambergreaſe*, and I take it to be the ſame with what they call the black *Ambergreaſe*; becauſe when purified, it is frequently ſold for a cheaper Kind of *Ambergreaſe*; *Dairiangao*, and *Raporago*, which ſmell like *Gum Benzoin*, *Tangay* and *Samato*, with others *Samata*, ſmelling like liquid Amber or Balſam) ſet it apart for Fumigation, and had almoſt conſumed the whole of it before ſhe was informed what it was. *Ambergreaſe* is frequently very adheſive, and there are many who affirm that it is ſometimes found as ſoft as Tar, which *Fran. Combes* ſeems likewiſe to inſinuate, when he ſays, that ſometimes it is gathered ſoft and recent upon the Shore, and after being kept and prepared, turns out extremely good. But the common Opinion is, which both *Hieronymus de Huerta* and *Fran. Combes* confirm, that the crude Ambergreaſe, or that which is new gathered, has no Sort of Fragancy. But *Job. Botero Benes*, f. 90. an *Ambergreaſe* Merchant at *Ava* ſays, that even when it is not adulterated, it has a very fragrant Smell, and ſo ſharp, as being held to the Noſe, to ſet it preſently a bleeding. *Alphonſus de Ovalle* in his Hiſtory of *Chili* writes, that the *gray Ambergreaſe* has a ſweet Smell, and the *black* a more pungent one, but this Difference of Smell and Colour proceeds from hence, that the black has been a ſhorter while in the Sea, and leſs expoſed to the Sun than the gray. * I therefore impute the Bleaching, Hardneſs, and Denſity of *Ambergreaſe* to the Sun, and the Sea Water, as *Thomas Bartholine* in the Medico-philoſophical Tranſactions at *Stockholm* in the Year 1671. *Obſ.* 57. f. 113. imputes the Solidity of *Amber* to the ſame Cauſes. I have a Piece of the whiteſt and fineſt Kind of *Ambergreaſe* bored in different Places, with five Shell Fiſh, and a Bit of rotten Wood ſticking in it. Which is a certain Argument, that the Goodneſs of it is owing to its being frequently waſhed, and long expoſed upon the Shore.

---

† *Caſpar Bayam* about the Year 1680, met with a very large Lump of *Ambergreaſe* in the Sea between *Aden* and *Meca*.

Of the Aſbeſtus, *and the way of making the* Incombuſtible Cloth, *by Seignior* J. Campini. n. 273. p. 911.

XXV. 1.] I have four ſorts of the *Aſbeſtus* in my *Muſæum*. The firſt from *Corſica* or *Corfu*, long, of a woody Form, of half a Palm length and more, of a whitiſh Colour, ſomething inclining to a reddiſh. The ſecond of a ſilveriſh Lead Colour, ſofter and ſhorter, about three Inches, this was from *Seſtri di Ponente* in *Liguria*. The third (which is the worſt of all) is like Scales or *Laminæ* one upon another (like an Onion) of a blackiſh Earth Colour, with ſome white, black, and dark red Veins, interſperſed, ſcarce two Parts of an Inch *Roman* long, therefore fitter for making of Paper, than ſpinning or weaving. The fourth ſort, given me by Signior *Boccone*, found in the *Pyrenæans*, ſome whereof were a *Roman* Palm long; its Filaments, though longer, were yet thicker and rougher; I have heard of another ſort in *Volateranis Montibus*.

Some have ſuppoſed, that the Wieks of the ſepulchral Lamps of the Antients were made of this; but from Experiments I conclude it unfit for that Purpoſe, always finding the Wieks made of it to go out, and not contract or continue up the Oil for the Flame.

I have kept it for 3 Weeks in a Glaſs-houſe Fire, but found it unalter'd; but it would not preſerve a Stick wrapt in it from the Fire; whence I conclude, the *Amiantus* loſes nothing in the Fire, becauſe it does not burn nor flame; but in the handling it waſtes, though not much, as I found by an exact Ballance.

---

* *Sennertus* upon Bitumen, thinks that the odorous *Ambergreaſe* is a Bitumen flowing from Fountains in the Sea, and when it is expoſed to the Air upon the Surface of the Sea, is thickened and coagulated in the manner of Amber.

As to the Manner of *Spinning* it, I have tried thus; firſt, I laid the Stone in Water (if warm, the better) for ſome Time to ſoak; then it is opened and divided with the Hands, that the Earthy Parts may fall out of it, which are whitiſh like Chalk, and hold the thready Parts together; this makes the Water thick and milky; this is repeated ſix or ſeven Times with freſh Water, where it is again opened and ſqueezed, till all the heterogeneous Parts are waſhed out, and then the Flax-like Parts are collected, and laid in a Sieve to dry.

Of the four ſorts of *Amiantus*, I found that from *Corſica* beſt, being long and ſoft; and the *Cyprian* worſt; I am in doubt, whether mine was of the beſt ſort, ſince the *Cyprian* was commended by *Pancirollus* and others. The Way of ſpinning it, diſcovered to me, was thus: Lay the *Amiantus*, cleanſed as before, between two Cards, ſuch as they card Wool with, where let it be gently carded, and then clapt up in between the Cards, ſo that ſome of it may hang out at the Sides; then lay the Cards faſt upon a Table or Bench. (*Fig.* 41.) Take a ſmall Reele, (*Fig.* 42.) made with a little Hook at the End, (*Fig.* 43.) and a Part to turn it by, (*Fig.* 44.) ſo that it may eaſily be turned round; this Reele is to be wound over with fine Thread; then having a ſmall Veſſel of Oyl ready, (*Fig.* 45.) with which the Fore-finger and Thumb are conſtantly to be kept wet, both to preſerve the Skin from the corroſive Quality of the Stone, and to render the Filaments thereof more ſoft and plyant: thus by twiſting the Thread upon the Reele about, with the *Aſbeſtus* hanging out of the Cards, ſome of it will be worked up together with it; by little and little this Thread may with Care be woven into a coarſe ſort of Cloth, and by putting it into the Fire, the Thread and Oyl will be burnt away, and the incombuſtible Cloth remain. But finding this Way of uniting the Stone with the Thread very tedious, inſtead of the Thread I put ſome Flax upon a Diſtaff, and by taking three or four Filaments of the *Aſbeſtus*, and mixing them with the Flax, I found they might eaſily be twiſted together, and the Thread thus made much more durable and ſtrong: So that there is no Need of carding, which rather breaks the Filaments, than does any Good; open only and ſeparate the Filaments after waſhing upon a Table, and take them up with the Flax, which is ſufficient. As to the making of Paper, in the waſhing the Stone, there will remain ſeveral ſhort Pieces in the Bottom of the Water, and of theſe after the common Method Paper may be made.

Fig. 39, 40.
Fig. 41.
Fig. 42, 43, 44.
Fig. 45.

The beſt Way of preſerving the Cloth, or any other Thing made of the Stone, when made (for by Reaſon of its exceeding Dryneſs it is very apt to break and waſte) is to keep it always well oyled, which is the only Preſervative for it; and when the Cloth is put in the Fire, the Oyl burns off, and the Cloth comes out white and purified.

——Aſbeſtus, &c. *found in* Scotland, *by Mr.* Wilſon, Brook, n. 276. p. 1000

2.] In the Grounds of *Francis Gordon* of *Achindore*, in the Shire of *Aberdeen*, near the *Highlands*, on the Side of a Hill of a Heath kind of Ground, ſomewhat inclining to what we call Moſs, in a very ſmall

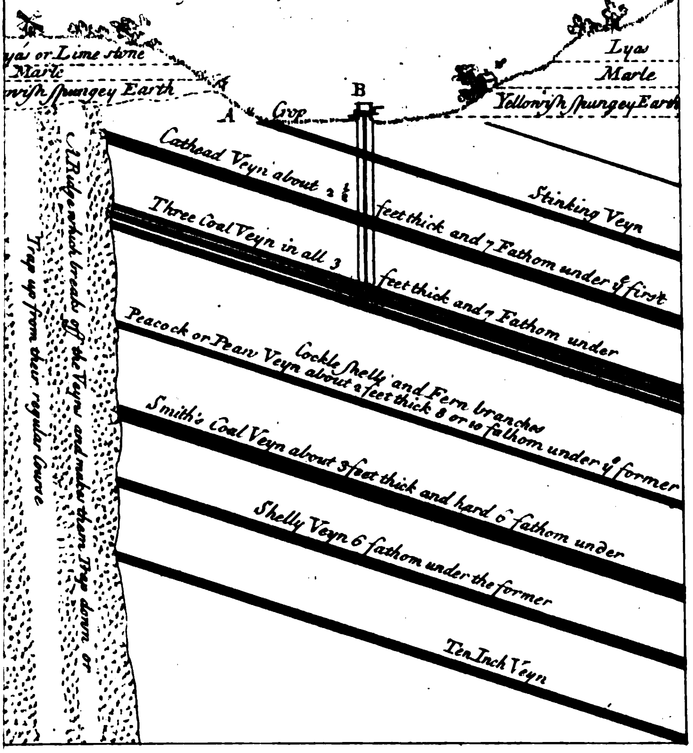
Brook, and hard by it, in the Bounds of ten or twelve Yards, I found a great many Stones, ſome a Foot in length, which appeared plainly like Wood: But becauſe I could not perceive any Footſtep of Wood thereabout, neither could any of them be found, except in that very Spot of Ground, I could not be perſuaded they were petrified Wood. Then I went to cut up the Ground about the Place with my Knife, where I found likewiſe ſome Pieces of the Stone, and very near the Superficies I got ſeveral Pieces of a fibrous Matter, which my Knife could not cut; this I immediately judged to be an *incombuſtible* Matter, as it proved afterwards, when I try'd it by the Fire. And becauſe, ſo far as I then remember'd I had heard or read of it, I thought it had been always eſteemed certain Filaments that came off the *Lapis Amianthos*, I reſolved to obſerve more narrowly the Production of it.

When I found ſome Pieces of the Stones very hard in the Middle, and the fibrous Matter on the Outſides and Ends, I was inclined to believe that the Flax came from the Stone: But then finding ſeveral Pieces of the Flax ſo condenſed and preſſed together, that at firſt they appeared to be hard Stones, but being a little wet, the Filaments were eaſily parted from one another. Many more I got, ſome leſs and ſome more condenſed into the Nature of a Stone; and all of it, both that which was condenſed together, and what was not, was lying about an Inch within the Ground, parallel with the Surface ſo interwoven with the Fibres of the Roots of the Graſs, that it ſeemed to me much more probable to believe, that the Lint turned into the Stone, than the Stone into the Lint: Eſpecially ſeeing moſt Part of the Stones appeared ſo tender and brittle on the Outſide, that it's hard to believe how they could turn into that tough Subſtance of Flax.

The Stones are of different Sorts, ſome are white, the Colour of the Lint, and of a very ſoft Subſtance; ſo they may be eaſily cut with a Knife without blunting it; others are much mix'd with a whitiſh *Talk*, but moſt of them are of a grayiſh Colour, and very hard.

As for the Production of the Flax, I think it's hard to determine in this Place; becauſe the greateſt Quantity I found of it was lying, as I ſaid before, about an Inch at moſt within the Ground, parallel with the Superficies, interwoven with the Roots of the Graſs, without any Root of itſelf, but alike at both Ends, as if it were cut with a Knife. The Ground wherein it is found is of a grayiſh Colour, about one Inch or two thick, under which there is a black Earth for a Foot in Depth. So that I could find nothing in the Places where moſt of it was got, that I could rationally conclude to produce it: But in ſome other Spots I found much of a *Talkiſh* Sand, and ſome Pieces of Flax near to it; as alſo Pieces of the Stone much whiter than the reſt, and very like *Talk*; which would incline one to believe that it was produced of it. Yet there being no Appearance of any *Talk* in the other Places, where moſt of it was found, I can ſcarce conclude any Thing about the Production of it, but leave it to others.

. Part II. Page 284.


yas or Lime stone
Marle
owish Spungey Earth
A
A
Gop
B
Lyas
Marle
Yellowish Spungey Earth
Cathead Veyn about 2½ feet thick and 7 Fathom under ye first
Stinking Veyn
Three Coal Veyn in all 3 feet thick and 7 Fathom under
Cockle shells and Fern branches
Peacock or Pean Veyn about 2 feet thick 8 or 10 fathom under ye former
Smith's Coal Veyn about 3 feet thick and hard 6 fathom under
Shelly Veyn 6 fathom under the former
Ten Inch Veyn
A Ridge which breaks off the Veyns and makes them Trap down or
Trap up from their regular Course

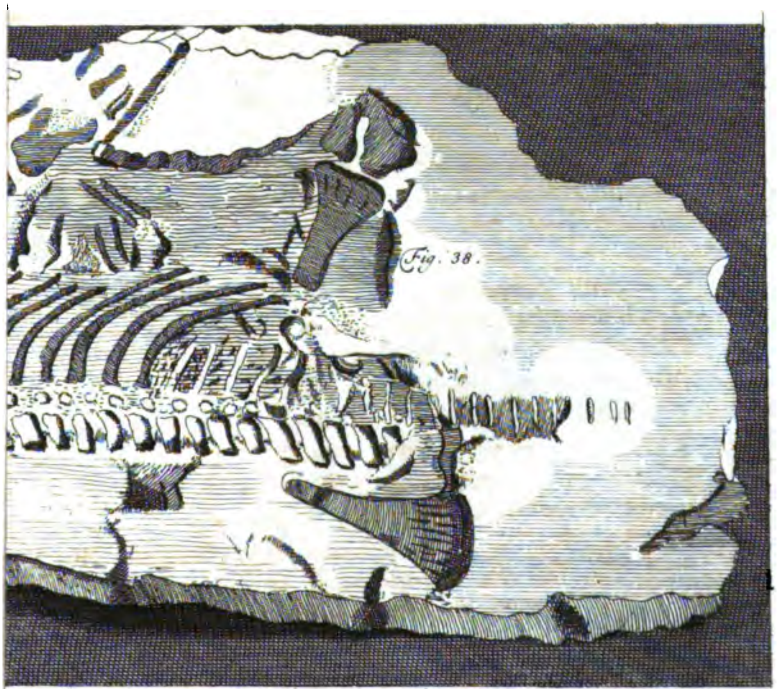


Fig. 38.

The Stone is 3 Foot long, and 2 Foot 2 Inches broad.

Pliny, *Aldrovandus*, and *Olaus Wormius* make it very ſhort, whereas ſome of this I found five, ſix, ſeven, and ſome eight Inches long.

As for the making of it into Cloth, they all conclude it very hard: *Pliny* calls it *inventu rarum, textu difficile propter brevitatem. Olaus Wormius* in his *Muſæum* ſays, *Modus vero, quo ex eo fiunt lina, jam penitus ignoratur*. I confeſs indeed, it is true what *Pliny* ſays; yet it may be ſeen, by the Experiment I have ſhewn, in making Yarn of it, that Cloth may be made of it alſo, for the Difficulty is much greater in the one than the other.

3.] I receiv'd the following Account from a Gentleman in the *Highlands*, (not many Miles from *Coupar* of *Angus*) who had lately built an Houſe of a *ſingular* kind of *Stone*, digg'd out of a Quarry not far from him. — *on the* ſame, *by Mr.* P. Blair. n. 333. p. 434. This Stone, after the Rubbiſh (which is not very deep) is done away, lies Horizontally in a Bed endu'd with parallel Fibres, with few Interſtices, ſoft at the Beginning, and eaſy to be ſmooth'd and poliſh'd without any Tool; but rather with Sand, or another hard Stone of a blueiſh Colour, which afterwards hardens ſo, that it reſiſteth the Injuries of Air or Prejudice of Fire. When firſt the Quarrier began to dig it, he was at a mighty Loſs; for endeavouring to cut and raiſe it after the ordinary Manner with Wedges, and other uſual Inſtruments, it broke and crumbled all to Pieces: But afterwards, obſerving more narrowly the Duct of its Fibres (ſo to ſpeak) he endeavoured to cut it with Spades lengthways; and by this Means he procured Stones as big as he had a Mind, which ſmoothed very eaſily along the Tract of their Fibres; but when cut tranſverſe, no Means nor Methods could render them ſmooth; but their Surface remain'd unequal as the Extremities of a Piece of Wood. Although this Quarry has but few Interſtices, yet in thoſe it has the true *Aſbeſtos*, of a whitiſh Silver Surface, conſiſting of ſeveral *faſciculi* with parallel Fibres, like to thoſe of the muſcular Fibres of ſalted Beef; eaſily ſeparable from each other, pure white, till it becomes ſo ſmall as the fineſt Flax; and ſo ductile, that it may be ſpun into the fineſt Thread, whereof it were eaſy to make the incombuſtible Cloth, ſo famous for Shrines among the Ancients. In other Places of thoſe Interſtices was likewiſe to be obſerved a reddiſh Subſtance, near to the Colour of *Sanguis Draconis*; but whether fibrous or not, I cannot ſay, ſince the Gentleman could not ſhew me any of it; but added, he believed it might be good for dying. I got a ſmall Parcel of the *Aſbeſtos* from him; and he told me, if he had known its Value, he could have preſerv'd ſome Pounds of it. I am ready to think the ſecond kind was fibrous too, which might make a very beautiful Cloth, being ſtriped with the other. This whole Quarry may be ſaid to be *Aſbeſtos* of different Colours, the blueiſh being of a much coarſer, and the white and red of a finer Grain.

XXVI. *Papers Omitted.*

1. A Deſcription of ſome *Shells*, brought from the *Molucca Iſlands*, by Mr. *Sylvanus Landon*, and Mr. *Rowleſton Jacobs*, by Mr. *J. Petiver*. n. 274. p. 927.

n. 282. p. 1266. 2. A Deſcription of ſome *Shells*, ſent from *Fort St. George*, by the Reverend Dr. *George Lewis* to Mr. *J. Petiver*, by the *ſame*.

n. 299. p. 1952. 3. An Account of ſome *Shells* and *Animals* ſent from *Carolina* to Mr. *J. Petiver*.

n. 286. p. 1419. 4. A Deſcription of ſome *Corals*, and other curious *Submarines*, ſent from the *Philippine Iſles*, by the Reverend *G. J. Camelli* to Mr. *J. Petiver*.

n. 301. p. 2042. 5. Catalogus *Concharum foſſilium, Metallorum, Mineralium*, &c. quæ a Cl. D. *Johanne Scheuchzero* nuper accepit D. *J. Petiver*.

n. 302. p. 2082. 6. *Mineralia* quædam, *Conchylia* petrefacta, & alia *Foſſilia* è *Berolino*, à Cl. *Chriſtian. Maximiliano Spenero*, Doct. Med. Reg. *Pruſſ.* Aul. Acad. S. R. I. Cur. & Soc. Scient. Reg. *Brandenburg.* Colleg. ad D. *J. Petiver* miſſa.

n. 311. p. 2397. 7. De *Conchyliis Turbinatis, Bivalvibus* & *Univalvibus*; item de *Mineralibus, Foſſilibus* & *Thermis Philippenſibus*, ex MSS. R. P. *Geo. Joſ. Camelli* communicavit D. *J. Petiver*.

n. 337. p. 222. 8. A ſhort Account of ſome *Swediſh Minerals*, &c. ſent from Mr. *Angeſtein*, Overſeer of the King of *Sweden*'s Mines, to Mr. *J. Petiver*.

n. 314. p. 77. 9. An *Advertiſement* of a *Catalogue* of ſeveral Specimens of *Figured Foſſils*, to be had of Mr. *Alban Thomas*.

XXVII. *An Account of a Book omitted.*

n. 291. p. 1604. Specimen *Lithographiæ Helveticæ* curioſæ, quo Lapides ex Figuratis *Helveticis* Selectiſſimi Ære inciſi ſiſtuntur & deſcribuntur, a *Johanne Jacobo Scheuchzero*, M. D. *Tiguri* 1702. 8*vo*.

CHAP. IV.

Magnetics.

Of the Invention *and* Improvements *of the* Mariner's Compaſs, *by Dr.* J. Wallis. n. 276. p. 1035. n. 278. p. 1106.

I. THE Doctrine of the *Magnet* has been, I believe, more improv'd by the *Engliſh*, than by any other Nation; and I am of Opinion, that the *Mariner's Compaſs* was originally an *Engliſh* Invention; not only becauſe *England* was of old as famous for Navigation as any other Nation, long before the *Holland* Sea-Trade was in being; but (ſince new Inventions commonly take their Names from the Place where the Invention itſelf is taken) from the *Name* itſelf of the Mariner's *Compaſs*.

The Word *Compaſs* (in Latin *Circulus Nauticus*) is an antient *Engliſh* Word, for what we otherwiſe now call by a *French* Name a *Circle*. In *Kent*, where I was born and bred, it was commonly uſed in that Senſe, when I was a Youth; and *Minſhew* in his Dictionary takes *Circle* and *Compaſs* indifferently to ſignify the ſame with *Circulus*: And hence it is that *Circinus* is in *Engliſh* call'd a *Compaſs*, (or a *Pair of Compaſſes*) as being the Inſtrument wherewith we deſcribe a *Compaſs* or *Circle*; but whether *Circinus*, call'd by us a Pair of *Compaſſes*, may have ſome like Name in another Language, I do not know, nor how antiently.

I do not know that the Word *Compaſs*, or any Word like it, was ever uſed in any other Language for a Circle *Indefinitely*, or for any *other* Circle than the *Circulus Nauticus*. In *French* it is *Cercle*, *Cerchio* in *Italian*, *Circulo* in *Spaniſh*, or ſome other Word deriv'd from the *Latin Circulus*; and from hence the *Circulus Nauticus* may come to be call'd the *Mariner's Compaſs*, which Name being given it by the firſt Inventors, might give Occaſion for like Names in other Languages, *French*, *Italian*, *German*, &c. *Compaſs*, *Compaſſo*, *Zee-Compaſs*, &c. which Name, together with the Art, I gueſs they borrow'd from *England*.

I might urge the ſame from another Name, *Boſſolo*, *Boſſola*, &c. For as *Circulus Nauticus* is the *Mariner's Compaſs*, ſo *Pyxis Nautica* is the *Mariner's Box*, (for the *Engliſh Box* is from the *Latin Pyxis*) and *Pyxidula* (as a Diminutive from *Pyxis*) muſt be *Boxel*, or ſome Word like it, which eaſily paſſeth into the *French Buxole*, *Bouſſole*; and the *Italian Boſſola*, *Bouſſula*; which all ſeem to be from the *Engliſh Boxel* (*Pyxidula*) *a little Box*; ſoftening the ſound of the Letter *x* in *ſſ*; as in *Aleſſandro* for *Alexandro*.

All which, though it be not a direct *Demonſtration*, yet (ſince it is not agreed by whom, or where the *Compaſs* was invented) may in the Silence of Hiſtory be admitted as a probable *Conjecture*, and a plauſible *Pretence* to the Invention, till a better claim do appear; for *New Inventions* commonly take their *Names* from whence the Invention itſelf is taken.

And where Inventions creep in by Degrees, it muſt not be thought ſtrange, if it be not eaſy to ſay, who is the *Firſt Inventor*.

In the preſent Caſe, he who firſt obſerved (I know not by what Accident) that the *Magnet* hath a *Polarity*, or Inclination Northward, made the *Firſt Step* towards this Invention. This (I think) was at firſt wont to be ſhewed, by putting a Magnet into a little Boat, ſwimming on Water, when it was obſerved, that this Magnet would of itſelf ſo ſteer this little Boat, as that a certain Point in the Magnet would (if not hindered) turn toward the North. Which Point was thereupon called the Magnet's *North Pole*.

He that afterward obſerved that this Verticity, or Polarity, was communicable to a Piece of Iron or Steel, rubbed on a Magnet, added a further Step.

And he who contrived a Way to ſet a Needle or Piece of Steel ſo [illegible] on a ſharp Pin, ſo as in the Air to move horizontally thereon, [illegible] as of itſelf to find out the North, and point toward it, as before the ſwimming Magnet in its Boat had done on the Water, had now diſcovered a new Experiment in Natural Philoſophy, very ſurprizing.

But this cannot yet be called *Circulus Nauticus* (or the *Mariner's Compaſs*) till they had further contrived a Way how to put a Needle thus poiſed into a Box, with a Compaſs or Circle round it; ſo divided as to denote the *Azimuthal* Points of the *Horizon*, or, as they be now called, the *Points of the Compaſs*; and ſo commodiouſly to fix this Box, ſo prepared, to the Ship, as thereby to inſtruct the Mariner or Steerſman toward what Point of the Compaſs the Ship moved; that by the Help of the Rudder he might put it into ſuch a Courſe, as was proper for his Voyage. And it was now indeed *Pyxis Nautica* or *Circulus Nauticus*, (the *Mariner's Box* or *Compaſs*) but not till then. And he who firſt contrived this Application, did *compleat* this Invention of *Circulus Nauticus*. But all thoſe antecedent Diſcoveries were Steps towards it, and Parts of the Invention.

Now it is not likely that all theſe Diſcoveries were made at once, by the ſame Man, at the ſame Time, but ſucceſſively, by the joint Advice of divers inquiſitive Men, and in a conſiderable Tract of Time; yet all perhaps of the ſame Nation, and probably the *Engliſh*.

But whoever gave the firſt Hint of this Invention, certain it is, that the great *Improvements* of the Magnetic Doctrine are due to the *Engliſh*, and chiefly to thoſe about *London* and *Greſham* College. And it is fit the Memory of it ſhould be preſerved.

The Caſe is much the ſame with that of *Printing*, which we cannot reaſonably ſuppoſe to be invented all at once, nor perhaps all by the ſame Man; but rather, by the concurrent Advice of divers, and in a conſiderable Tract of Time, before it came to that Degree of Perfection which we now call *Printing*.

It might be firſt obſerved, that the Shape of a Letter, Figure, or Picture, graven on Wood or Metal, might (with help of a convenient Preparation of Oil, Ink, or coloured Liquor) be ſtamped on Paper; and, if once, then as oft as you pleaſe.

And if by ſtamping the Print on Paper, then as well by due Application of the Paper to the Print, thus prepared.

And if one, then by the ſame Reaſon to two or more, if fitly conjoined, and even to a whole Page at once; and, of that, as many Copies as we pleaſe.

But, this being admitted, it remains further to be contrived, how all theſe Prints or Stamps for a whole Page ſhall be ſo composed into one Frame, that the Paper may be applied to all at once.

It is then to be conſidered farther, what kind of *Ink*, (or ſomewhat inſtead of Ink) is to be applied to the Face of the Letters, thus compoſed; for common Writing-Ink will not ſerve the Turn.

Then, how the Paper ſhall be applied (with an equal Preſſure and ſufficient) ſo as to take off juſt ſo much of that Ink, as repreſents the Face of thoſe Letters, and no more.

And after all this, it muſt be further contrived, how to erect ſuch a Structure, as what we now call a *Printing-Preſs*, and how to manage it, ſo as to anſwer all theſe Exigences: For, till all this be done, we are not arrived at what we call *Printing*. But all thoſe previous Contrivances, muſt be owned as *Parts* of the *Invention*.

And in the *Magnetic Doctrine* likewiſe. And to thoſe *previous* Diſcoveries, muſt be added, the *ſubſequent* Improvements of Magnetic Knowledge, ſince the firſt *Uſe* of the *Mariner's Compaſs*.

But whoever was the firſt Inventor of the *Mariner's Compaſs*, it is certain, that the *Doctrine* of the *Magnet* has receiv'd very great Improvements from the *Engliſh*; from *Blagrave*, *Gunter*, *Gellibrand*, *Gilbert*, *Norwood*, *Wright*, *Brigs*, *Foſter*, &c. and of late by Capt. *Halley* in his *Map* of the *Magnetic Variations*; which I look upon as an excellent Deſign, well contriv'd, and well executed, and which fixes the Buſineſs of the Magnetic Variation in theſe Seas for the *preſent* Time.

I think it is agreed on by all Hands, that what we call *the Variation of the Needle*, is an *Engliſh Diſcovery*, (of Mr. *Gellibrand*, if I miſtake not, one of Sir *Thomas Greſham*'s Profeſſors at *Greſham* College) about the Year 1625. that is, that the *Magnetic Needle* in its horizontal Poſition doth not retain the ſame *Declination* or *Variation* from the true North, in the ſame Place, at all Times, but doth ſucceſſively vary that Declination from Time to Time; which, though it were about that Time a *New Diſcovery*, is now admitted as an undoubted Truth.

It was about the Beginning of the Reign of King *Charles* the Firſt, that Mr. *Gellibrand* (if I have not been miſinformed) cauſed the Great *Concave Dial* to be erected in the *Privy-Garden* at *Whitehall*, with great Care to fix a true *Meridian-Line*; and with a large *Magnetic Needle*, ſhewing its *Variation* from that *Meridian* from Time to Time. And I think it were not amiſs, if exact Obſervation were now made, whether the *Meridian* be now juſt the ſame as it was then; for it is very poſſible, that the *Pole* of the Earth may in Time ſuffer ſome little Variation (which may not readily be diſcerned) which may cauſe an Alteration of the *Meridian* Line: And this, if ſo, will be more diſcernible nearer the Pole, than farther off.

What we call the *Dipping Needle*, is admitted alſo to be an *Engliſh* Diſcovery, (I think of Mr. *Blagrave*'s) ſomewhat older than the former, that is, that the *Magnetic Needle*, beſides its *Horizontal* Direction toward the North, hath alſo a Direction of *Altitude* above the Horizon, if ballanced on an Horizontal Axis; pointing, as it were, with its Northern End in our Climate to ſome Point within the Body of the Earth. Whether or no this Direction do vary from Time to Time as doth that of its Horizontal Poſition Northward, I cannot tell; nor do I know whether or no it hath been yet obſerved; nor whether or no the Southern End in other Parts of the World do *dip*, as the Northern End doth with us.

'Tis alſo an *Engliſh Obſervation*, that not only a *Magnetic Needle*, but any Piece of *Iron* (if kept long in the ſame Poſture) ſhall of itſelf contract a *Polarity*. As for Inſtance, an erect Bar in a Window, after long Continuance in that Poſition, will, if duly poiſed, be found with its upper End, to point toward the North; and Southward with the other End. And if afterwards it be continued long in a contrary Poſition, it will attain a contrary Polarity.

And Mr. *Gilbert*'s Notion (of the Earth's whole Body being but one great Magnet; and, leſſer Magnets being ſo many *Terrella*'s, ſympathizing with the whole) is *Engliſh* alſo.

It hath been obſerved alſo, that a magnetic Needle, if heated red-hot, will loſe its Polarity; and, if then cooled in a contrary Poſition, will acquire a contrary Polarity.

It hath alſo been obſerved by our *Engliſh* Mariners, (and, I think, more than once) that, upon a great Flaſh of *Lightning* at Sea their Magnetic Needle hath loſt its former Polarity, and contracted the contrary.

In general, the Doctrine of *Magnetiſm* hath been more improved by our *Engliſh* Naturaliſts, than (for ought I know) by any other Nation. And, if ſome one would take the Pains to give us a true Hiſtory of theſe (and the like) Improvements, it would be an acceptable Work, and for the Honour of the Nation.

Magnetical *Experiments and Obſervations, by Mr.* W. Derham. n. 303. p. 2136.

II. 1.] Having lately invented an *Azimuth Compaſs*, as I was preparing it for obſerving the *Magnetic Variation*, I took Occaſion to try divers Magnetic Experiments, and by that Means happened upon this odd *Phænomenon*.

Having touched a Piece of Wire, ſo that it ſtrongly tended N. and S. I was minded to ſee whether it would have any Inclination to either of the Poles of the World, when turned round like a Ring, ſo that the two Ends of the Wire met: And having again ſtraightened it, I was ſurprized to find it had quite loſt its *Verticity*; the Cauſe of which, I preſently concluded, to be the Contact of the Northern and Southern Ends of the Wire, which I thought might ſo influence one the other, as to confuſe its Poles; although I confeſs I had never obſerved any ſuch Confuſion to ariſe upon the bare Contact of the Northern and Southern Ends of two other touched Pieces of Wire.

Upon this, I touched ſtrongly the ſame, and other Pieces of freſh Iron Wire, and having found them all greedily to turn N. and S. I coyled them round ſo as that the Ends ſhould not come near one another, and again ſpeedily opened them ſtraight; and found, as before, that every Piece had utterly loſt its *Verticity*: Nay, the *Magnetic Virtue* was ſo abſolutely deſtroyed by bending the Wire, that it had not only loſt its Inclination to either Pole, but the two Ends of each Wire ſeemed indifferent to the Poles of the *Loadſtone*, *viz.* whereas before the bending, the adverſe Poles of the *Loadſtone* would repel, and the ſimilar Poles attract the adverſe, or ſimilar Ends of the Wire; now the repulſive Virtue was quite extinguiſhed, and either End would indifferently be attracted by either Pole of the Magnet; all one as if the Wire had been heated red-hot (which is well known to deſtroy the Virtue) or never had been touched at all.

This I experimented over and over again upon Wires of different Lengths, with the ſame Succeſs. Only this muſt be obſerved, if you only bend the Wire round, ſo as that it ſhall ſpring back into its Place, or recoil, ſo as to be near the ſame Straightneſs, that then no ſuch, or but little of ſuch, Effect will enſue. But to produce this Effect, the Wire muſt be *ſharply* bent, ſo as that *Violence* may be exerted upon it. If it be coyled two or three times round a ſmall round Stick, it will beſt ſucceed. And farther alſo, it is neceſſary that every Part of the Wire ſhould be bent, to evacuate the Magnetic Virtue: For if the Ends, or any other Part happen not to ſuffer the Violence of bending, that Part ſhall retain its Magnetiſm: As for Inſtance, if the Wire be all coyled, except half an Inch, or indeed half a tenth of an Inch at each End, every Part ſo coyled ſhall both loſe its Verticity, and ſhall incline indifferently to either Pole of the Magnet; but the two Ends (although not able to turn the whole Wire N. and S.) ſhall fly from, or tend unto the reſpective Pole of the Magnet: Or if every Part of the Wire be coyled, except a ſmall Bit at one End only, all that coyled Part, when extended, ſhall utterly be deprived of its Magnetiſm as before; and only that uncoyled Bit retain its Averſion, or Inclination to the Magnetic Poles.

From the Conſideration of all which Particulars, it is very manifeſt, that the Violence exerted upon the Wire by bending, doth utterly extirpate the Magnetic Virtue, or at leaſt make ſuch a Confuſion therein, that it is as if wholly deſtroyed: Which is a Caſe very odd, and never (that I have ever met with) taken Notice of before.

Further *Obſervations on the ſame, by the ſame. ibid.* p. 2138.

2.] The Account which I lately gave of the *Deſtruction of the Magnetic Virtue* in a touched Piece of Iron Wire, by *Bending*, or *Coyling round*, I thought had been New: But by looking over what others have written of Magnetics, I find in *Grimaldi de Lumine & Colore*, that he, and in our *Phil. Tranſ.* N° 188. * that M. *de la Hire* had hit upon the ſame Diſcovery before me. And I am glad that I have the Authority of others on my Side, the Experiment not ſucceeding in ſome Tryals ſince.

* *Vid.* Supra. V. II. C. IV. S. IX.

The Matter of Fact was thus, and to me ſurprizing: I touched and coyled ſeveral Iron Wires, but the Effect that enſued was not ſuch as I told the Society. The Verticity was indeed much weakened, but not totally deſtroyed, and the Ends of the Wires would be attracted or repelled by the Poles of the Magnet; whereas I ſaid they uſed only to be attracted. The next Morning I tried again; and then the Magnetiſm of the Wires was totally deſtroyed, as I related. This Experiment I repeated divers Times, and on divers Wires this Winter, and commonly find, that, all the Day, coyling will evacuate the Magnetiſm; but that it will not abſolutely do it in the Evenings. But whether it will do ſo in Summer, or all Weathers, or whether it ſucceedeth thus only in different Times of the Day, I muſt leave to farther Tryals. I well know that the Orb of the Activity of Magnets, is larger, or leſs, at different Times. That noble Magnet in the Society's Repoſitory, found in *Devonſhire* by Dr. *Cotton*, is known in ſome Weathers (or at ſome Times) to keep a Key, or other Piece of Iron, ſuſpended to another Iron, at 8, 9, or 10 Feet Diſtance. But at other Times, the Iron will drop down at the Diſtance of 3 or 4 Feet from the Magnet. Now whether at all, or how far this may reach the fore-mentioned Caſe, I cannot ſay, not having as yet ſufficiently experimented the Matter.

Finding the Caſe thus with *Coyled*, or *Bent Wire*, I was minded to try the Event of *Twiſting* of Iron Wire from End to End, after it had been well touched. The Succeſs was, the *Verticity* was always weakened, and ſometimes inverted. And when it was ſo, the Load-ſtone did accordingly commonly repel or attract, all one as if the twiſting the Wire had given a new Touch the contrary Way.

But in ſome Wires ſo twiſted the Verticity was wholly deſtroyed, or rather much confuſed: For I found by drawing one of the Poles of the Load-ſtone along near the Sides of the Wire, that in ſome Places it would attract, in others repel, and ſo attract and repel all along the Wire. Nay, I fancied in ſome Places, that one Side of the Wire would be attracted, the other repelled by one and the ſame Pole of the Load-ſtone.

To theſe odd Changes I could add divers others, which the *Twiſting* produced: But theſe do ſufficiently ſhew, that the Magnetic Virtue is put into great Confuſion by the Violence exerted upon the Wire by *Twiſting*: Which not only ſeparateth the Fibres of the Iron (as may be ſeen with the Eye, eſpecially aſſiſted with a Microſcope) but alſo changeth their Situation from Longways to Screw-ways.

I then try'd what would be the Iſſue of *Splitting* or *Cleaving* touched Wires: Particularly whether they would exert the ſame Effects that Magnets are ſaid to do, when ſawn in two Meridionally. Concerning which Dr. *Ridley* ‖ ſaith, "Cut a Piece from a Magnet-ſtone meridionally, and that End which was placed S. when it was whole, being ſevered, will turn North, although naturally at firſt it was the S. Point." But Mr. *Barlow* is of a contrary Mind, and ſaith, That the Poles of ſuch a Piece of Magnet, when ſevered, will abhor the ſame Poles, to which it grew in the whole Magnet. But he ſubjoins †; "But here you muſt beware of an Error, which ſome unhappily have entangled themſelves withal, who beholding the aforementioned Diſcord, wrongfully ſuppoſed, that if both theſe Magnets the greater and the leſs [*i. e.* the Piece cut off] were conveniently placed to ſwim in Water, the little one would not with his End point unto the South of the Earth as it did in the Magnet being entire, when it was a Part of the true North End, but would point contrarily. There is (ſaith he) no Manner of any ſuch "Alteration,

‖ *Treatiſe of* Magnet. Bodies *and* Motions. Ch. 9.

† *Magnet. Advertiſements.* Ch. 2.

" Alteration, but that both the great one, the little one, and all the
" like, that are cut Meridionally one from another, will abſolutely
" point the ſame Way which the entire one did. Only the Meridian
" will be ſomewhat removed, &c."

Dr. *Gilbert* is as expreſs as Mr. *Barlow.* For (*L.* 2. *c.* 5.) ſpeaking of a Magnet divided, and ſhewing how that the Parts, which in the whole Stone coaleſced, do by Separation repel one another, he ſaith, *That what was the N. and S. Pole before, is ſuch ſtill. Non enim* (ſaith he) *immutatur Verticitas (quod malè affirmat* B. Porta.) *Nam licet* {*Poli ſeparati*} *non conveniunt, ut alter ad alterum inclinaret; tamen uterque in idem Horizontis punctum convertuntur.*

How the Truth lieth between Dr. *Ridley* and the two latter Authors, I cannot determine, having never ſo cut a Magnet. But by the Magnetic Laws, as well as from the Authority of Dr. *Gilbert* and Mr. *Barlow*, I doubt not but the latter is the trueſt Opinion.

But in *Cleft Wires* the Caſe is very uncouth: Oftentimes the Poles are quite changed: So that what was the *North*, becometh the *South* Pole of the Wire in all Reſpects; I mean, not only turning, but alſo embracing, or avoiding the Poles of the Load-ſtone, as if it had received a new, and contrary Touch. Sometimes one half of the Wire will retain its Magnetiſm, which it had before ſplitting, and the other half have it quite changed. Sometimes no Change at all will enſue, only the Magnetiſm be much weakened; as indeed it always is in all the Experiments where the Wire is ſplit. (But generally, where one of the Halves hath ſuffered Change, the other not, I have obſerved, that 'tis the thinneſt and weakeſt that hath been changed, and the thickeſt hath retained its Touch.) Sometimes where one of the ſplit Halves received an *inverted Verticity*, or ſeemeth to have no Verticity at all, one of its Ends will incline to one of the Poles of the Magnet, not according to its Touch, but in an inverted Order, and the other End be attracted indifferently by both the Poles of the Loadſtone. And in ſome Caſes, that End ſhall be attracted by one Pole, but be neither attracted nor repelled by the other; but ſtand as it were heſitating whether it had beſt fly to, or from that Pole of the Loadſtone. Only if that Pole of the Magnet be too near, then that End of the Wire will conſtantly fly thereto: As indeed it is the Nature of all Magnets and Magnetic Bodies to do, when they touch or approach very near one another, though they repelled before.

The Cauſe of theſe great Changes in touched Wire produced by *Splitting*, I have ſometimes imagined to ariſe from the Violence exerted thereon by bending. But in ſome Wires that I ſplit, or cleft with very little bending, one half hath been utterly changed, the other not.

In others that I cleft, by ſuffering the Halves to bend as much as they would, no Change hath been; and ſome have quite ſuffered Change.

Sometimes I have imagined that the Splitting the Wires in a N. or S. Poſition, or that the Beginning to ſplit at the N. or S. End of the Wire firſt, might be the Cauſe of this Contraverſion of the Poles. But Trials ſhewed there was little in any of this.

Thus I would have done with *Split* or *Cleft Wires*; but there is one Thing very ſurprizing, *viz. That the laying one, or the other Side of the Half uppermoſt*, will cauſe a great Alteration in its Tendency, or Averſion to the Poles of the Magnet (as I have ſaid). But if you lay the contrary Side of that Half uppermoſt, the ſame End ſhall be attracted by one, and repelled by the other Pole of the Magnet. In other Pieces, where the Ends are regularly attracted or repelled, only in an inverted Order (as if new touched) if it lay with the round Side uppermoſt at that Time, and be then turned upſide down, *viz.* the flat cleft Side uppermoſt, 'tis ten to one if one of the Ends be not either attracted by both the Poles, or repelled by both; or elſe attracted or repelled by one, and heſitates as to the other. For ſo it often befals.

The Cauſe of this Lubricity of the Magnetiſm, I imagined might be, becauſe the Sides or Edges of the Wire had received contrary Poles by Splitting: And conſequently were turned topſy-turvy, that what was the N. might then be the S. Edge of the Half. But I could never diſcover but that the Sides of each End, or of any other Part, were the ſame, when I held the Loadſtone to one or the other Side. Which indeed I always did in every Experiment for greater Certainty Sake.

My Hand being in, I try'd the old Experiment of touching Wires, *by rubbing them backwards and forwards* with one of the Poles of the Loadſtone, becauſe it might probably give ſome Light into the aforementioned ſtrange *Phænomena.*

Mr. *Barlow* was I think the firſt that diſcovered the Error of this Way of Touching, *viz.* That it weakeneth or much hurteth the Touch. This I try'd, and found what is ſaid not only to be true, but alſo that the Reaſon thereof is, *Becauſe the Poles of the Wire, or Needle, ſo touched, are not at the Ends, but in or near the Middle of the Wire or Needle.* Sometimes one is near the Center, the other at one or both Ends. For in ſome Wires ſo touched, both the Ends of the Wire would be attracted by one Pole of the Loadſtone, and repelled by the other: And in ſuch Caſe the repelling Pole always found a ſympathetic Part near the Center of the Wire. In others (eſpecially where a Verticity ſucceeded, as ſometimes it will do, and that pretty ſtrongly too, in ſuch a Caſe) the Verticity would be inverted, and the Ends of the Wire be attracted and repelled in a direct contrary Manner to the Natural Form. And the Reaſon of all this will be manifeſt from theſe following Experiments.

I touched a Wire from End to End with only one Pole of the Magnet: This gave ſo vigorous a Touch, that I am almoſt of Opinion, *It is the beſt Way of Touching.* The Conſequence was, the End where

I began always turned contrary to the Pole that touched it. I again touched the ſame Wire, and others too with the other Pole of the Magnet, from the ſame End, and then that End turned the contrary Way, *e. g.* Mark one End of a Wire for the North End, and touch that Wire, by drawing the N. Pole of the Magnet divers Times along the Wire from the N. to the S. End; this Wire, ſo touched, ſhall have a vigorous Verticity, but the North End ſhall ſtand South: But if you touch that, or another Wire, (for it is all one, becauſe the latter deſtroys the former Touch; I ſay, if you touch) by drawing the N. Pole of the Magnet from the S. to the N. End of the Wire, then this N. End will turn N. And ſo it will do the ſame, if you touch with the Southern Pole from the N. to the S.

There is one Experiment more, doth yet give farther Light into what goeth before, *viz.* I touched an Iron Wire exactly in the Middle with only one Pole of the Loadſtone, without drawing it backwards or forwards. The Event was, that in that Place that Pole of the Wire was, and the two Ends were the contrary Pole of the Wire, and were accordingly repelled or attracted by the Poles of the Loadſtone: And the Middle, and an Inch or more on each Side, was attracted by the Pole only that touched it.

If we reflect and compare the foregoing Experiments one with another, they not only illuſtrate one another, but ſeem to lay open a fair Way towards the Diſcovery of a great many of the intricate *Phænomena* of Magneticks.

Experiments concerning the Proportion *of the* Power *of the* Loadſtone *at different* Diſtances, *by Mr.* F. Hawkſbee. n. 335. p. 506.

III. 1.] Without mentioning the Difficulties that attend the making of Experiments of this Nature, I ſhall give an Account of their Succeſs. I took a Quadrant of four Feet Radius, and having fix'd it to the Floor, in the Poſition of the Needle, whoſe South Point directed itſelf to no Degrees, I then fix'd a Board (likewiſe on the Floor) in a direct Angle from the ſame, the Graduations on which Board were 3 Inches diſtant from each other. The Needle was ſuſpended on a Point ariſing from the Center of the Quadrant, from whence were meaſured the ſeveral Stations of the Magnet. The Magnet was laid on a thin Piece of Board, under which, to one Side was nail'd a narrow Slip of Wood, to ſlide it along the Side of the foremention'd graduated Board, whereby the Stone might be always kept in the ſame Direction to the Needle. The Stone that I uſed, weighed about ſix Pounds; was rough, and of an irregular Figure; yet I could diſcover no Inconveniency in the Experiment ariſing from the ſame, it being, and acting at all Diſtances in the ſame Poſition as it is firſt plac'd on the Board: And I ſee no Reaſon to doubt, but the Proportions of its Power will be regular, and agreeable to the ſeveral Diſtances, as more than once I have obſerv'd. For when the Stone hath been differently poſited on the fore-mention'd thin Board, different Angles of the Needle would enſue at the ſame Stations, yet their Proportions one to another would be nearly the ſame. My

Meaning is this: Suppoſe the Stone was ſo plac'd, as at 3 Inches from the Needle, it would give the Needle an Angle of 90 Degrees, the Stone being continued in the ſame Direction, at the ſeveral Stations, the Proportions of its Power one to another would be much the ſame, as if the Angle of the Needle at the firſt Beginning made but 87, or even but 80 Degrees on the Quadrant; for upon a ſmall Alteration of the Poles of the Stone, ſuch Diverſity of Angles will ariſe.

In theſe Experiments I made uſe of two Needles, one of a *Radius* of 6 Inches, the other but one Inch; which laſt, after many Trials, I found to be moſt accurate, beſides the Advantage it gave in beginning the Experiment 6 Inches nearer the Stone, than the other; and from two Feet Diſtance from the ſame, it became nearly agreeable to the Angles made by the long Needle to all the farther Diſtances; as you will find by the following Tables, which were made with the ſeveral Needles in the ſame Direction of the Stone. I meaſured the Angles by a Silk Thread ſtrained directly over the Needle to that Part of the Quadrant to which it was directed; which was the beſt Way I could contrive to come neareſt the Truth.

It may be obſerv'd from the following Tables, that the long Needle at 9 Inches from the Stone, made ſomewhat a larger Angle than the ſhort Needle at 3 Inches Diſtance from the ſame; that the ſhort Needle at the Diſtance of 9 Inches, made an Angle of 9 Degrees leſs than the long one at the ſame Place. But this Odds will eaſily be accounted for, if we conſider the Diſproportions of the Needles Lengths; for the Point of the long Needle at 9 Inches, was brought within an Inch as near the Stone, as the Point of the ſhort Needle was, when but 3 Inches diſtant from the ſame: The Point of the ſhort Needle at 9 Inches from the Stone, was 5 Inches farther from it, than the long one at the ſame Station. Theſe Diſproportions being conſider'd, it is no Wonder ſuch Difference of Angles ſhould enſue upon the Uſe of the ſeveral Needles near the Stone; for at two Feet, and the farther Diſtances, they become nearly agreeable, as I ſaid before. When I ſpeak of Diſtances from the Needle, I always mean from the Center of it.

Farther it is obſervable, that the Stone at 5 Feet Diſtance from the Needle made an Angle of 2 Degrees with one, and with the other of two and a half; yet upon the Abſence of the Stone, they would return to no Degrees, as at firſt: Which plainly ſhews, that the Influence of the Stone extended farther; although Obſervations, at remoter Stations, could not eaſily be determined.

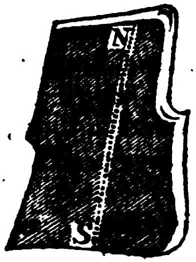
At greater Diſtances, and even the more remote in theſe Tables, the Power of the Stone is ſo weak, and the meaſuring the Angles at all Times exactly, ſo difficult, that 'tis well if we come ſometimes within 10 or 20 Minutes of the Truth.

Experiments by the ſhort Needle.

Diſtances of the Load-ſtone from the Needle in Inches.	The ſeveral Angles of the Needle at the ſeveral Diſtances.	The differences compared one with another, at the ſeveral Obſervations, in Minutes.
	D	
3	87 — 00	180
6	84 — 00	330
9	78 — 30	570
12	69 — 00	735
15	56 — 45	795
18	43 — 30	630
21	33 — 00	540
24	24 — 00	360
27	18 — 00	270
30	13 — 30	150
33	11 — 00	135
36	8 — 45	105
39	7 — 00	90
42	5 — 30	60
45	4 — 30	40
48	3 — 50	30
51	3 — 20	20
54	3 — 00	15
57	2 — 45	15
60	2 — 30	00

Experiments by the long Needle.

Diſtances of the Load-ſtone from the Needle in Inches.	The ſeveral Angles of the Needle at the ſeveral Diſtances.	The differences compared one with another, at the ſeveral Obſervations, in Minutes.
	D	
9	87 — 30	345
12	81 — 45	570
15	72 — 15	1137
18	53 — 20	1100
21	35 — 00	660
24	24 — 10	380
27	17 — 50	280
30	13 — 10	180
33	10 — 10	130
36	8 — 00	90
39	6 — 30	75
42	5 — 15	65
45	4 — 10	40
48	3 — 30	30
51	3 — 00	25
54	2 — 35	20
57	2 — 15	15
60	2 — 00	00



The Stone with which theſe Experiments were made, was of this Form, and weigh'd exactly ſix Pound, one Ounce, and a Quarter, Averdupois-Weight. Its Breadth at the North-pole was four Inches, at the South-pole five Inches; the Poles running through the Stone, in the Direction of the prick'd Line. The Length of the ſhorteſt Side was ſix Inches and a Half, and of the longeſt Side ſeven Inches and a Half. Its Thickneſs at the North-pole was one Inch and a Half, and at the South-pole one Inch.

2.] By Order of the *Royal Society*, Mr. *Hawkſbee* and myſelf made an Experiment with the great Loadſtone belonging to the Society, in order to diſcover the Law of the Magnetical Attraction, an Account of which I gave to the Society, in a Letter to Dr. *Sloane*, dated *June* 25, 1712. Since that, Mr. *Hawkſbee* made another Experiment of the ſame

An Account of an Experiment *to diſcover the* Law *of the* Magnetical Attraction, *by Dr.* B. Taylor. n. 344. p. 294.

ſame Nature with a ſmaller Loadſtone; upon comparing the Numbers of that Experiment with thoſe of the other, I find the Numbers of the firſt Experiment to be very much more regular; wherefore I conclude the firſt Experiment to be the beſt. It was made in the following Manner:

We placed the Great Loadſtone belonging to the *Royal Society* ſo, that its two Poles lay in the Plane of the Horizon, and were in a Line exactly at Right Angles with the natural Direction of the Needle we made uſe of (which was that Dr. *Halley* had made to obſerve the Variations with:) And by means of a Carriage contriv'd for that purpoſe, the Stone was eaſily moved to and fro, the Poles continuing always in the ſame Line. The Needle was ſo placed, that the Center it play'd upon, was in the ſame Line with the Poles of the Stone; the North-pole being towards the Needle. We meaſur'd the Diſtances from the Center of the Needle to the Extremity of the Stone: and we found the Variations of the Needle from its natural Poſition, to be as in this Table.

Diſt. Feet.	*Variat.*	
1	81	45
2	58	00
3	30	00
4	16	00
5	9	20
6	5	35
7	3	30
8	2	20
9	1	35

CHAP. V.

Agriculture. Botany.

Of the Manuring *of* Lands *by* Sea-ſhells *in* Ireland, *by the Archbiſhop of* Dublin. n. 314. p. 59.

THE Counties of *London-Derry* and *Donegal* in *Ireland*, are very mountainous, and thoſe Mountains covered with Bogs and Heath, inſomuch that there is little Arable Ground in them, except what has lately been made ſo. There are three Ways practiſed to reduce Heath and Bog to Arable Land: The firſt is, by cutting of the Scurf of the Ground, making up the Turf ſo cut in Heaps, and when the Sun has dried theſe Heaps, they are then ſet on *Fire*; when burnt as much as they can be, then thoſe Heaps are ſcattered on the Ground, and it being ploughed, it beareth Barley, Rye, or Oats, for about three Years.

The Inconveniences are, firſt, that ſuch Burning defiles the Air, cauſeth Rain and Wind, is not practical in a wet Summer, and by deſtroying the Sap of the Earth and Roots of the Graſs, and all other Vegetables, renders it uſeleſs for ſeveral Years after the third, in which it is ploughed.

The ſecond Way is by *Liming*; this is much better than the former, becauſe it doth not ſo much depauperate the Ground, will laſt long, and beareth better Grain, and whatever is pretended, doth not deſtroy the Graſs, if due Care be taken not to over-plough it; but then this is very dear, and Lime-ſtone is not every where to be had, and in many Places Fire is wanting.

Dung is the common Manure in all Places, and therefore I ſhall ſay nothing of it.

Marl is not uſed, that I have obſerved, in the North, but about the Sea-ſide the great Manure is *Shells:* Any one that will look into the Map, will ſee how the Bay of *London-Derry*, commonly called *Loughfoyle*, lies; towards the Eaſtern Part of it there lie ſeveral Eminencies that hardly appear at low Water; theſe are made of Shells of Sea-Fiſh of all ſorts, more particularly of Perewinkle, Cockles, Limpet, *&c.* The Country Men come with Boats at low Water, and carry Loads of theſe Shells away; they leave them in Heaps on the Shore, and there let them lie till they drain and dry, and by that Means become much lighter for Carriage; they carry them by Boats as far as the Rivers will allow them, and then in Sacks on Horſes, perhaps ſix or ſeven Miles into the Country; they allow ſometimes 40, but moſtly 80 Barrels to an Acre; they agree with boggy, heathy, clayey, wet, or ſtiff Land, but not with ſandy. They ſeem to give the Land a ſort of Ferment, as Barm doth to Bread, opening and looſening the Clods, and by that Means making Way for the Roots to penetrate, and the Moiſture to enter into the Fibres of the Roots: The Manure continues ſo long, that I could find none that could determine the Time of its enduring.

The Reaſon of its long Continuance ſeems to be this, that the Shells melt every Year a little, till they be all ſpent, which requires a conſiderable Time, whereas Lime, *&c.* operates all in a Manure at once; but it's to be obſerved, that in ſix or ſeven Years the Ground grows ſo mellow, that the Corn that grows on it becomes rank, and runs out in Straw to ſuch a length, that it can't ſupport itſelf, and then the Land muſt be ſuffered to lie a Year or two, that the Ferment may be a little quieted, and the Clods harden, and then it will bear as long again, and for ought I know and could find, it continues to do ſo with the like Intermiſſions for 20 or 30 Years.

In the Years in which the Land is not ploughed, it bears a fine Graſs, mixed with Daiſies in Abundance; and it is pleaſant to ſee a ſteep high Mountain, that a few Years before was all black with Heath, on a ſudden look white with Daiſies and Flowers.

It fines the Graſs, but makes it ſhort, tho' thick. Obſerving that this Manure produced Flowers in the Field, I made my Gardener uſe theſe Shells in my Flower-Garden, and never ſaw better Carnations, or Flowers fairer or larger than in that cold Climate; and it contributes to deſtroy Weeds, at leaſt doth not produce them ſo much as Dung; it likewiſe produces very good Potatoes at about a Foot Diſtance from one

Potatoes.

one another; and this is a Method of reducing boggy barren Land. They lay a little Dung or Straw on the Land, and ſprinkle it with Shells; ſometimes they cut the Potatoes, if large, that they may go the further, and then dig Trenches about ſix or ſeven Feet Diſtance, and throw the Earth or Soil, they take out of them, on the Potatoes, ſo as to cover them, and then fencing the Plot of Ground ſo planted, let them grow. Plant them in *April* or *May*, and they are ripe in *Auguſt*; they dig them as they have Occaſion, and let them lie till next Year, then dig them again, and ſo the third Year; every Year they by this Means go deeper in the Earth, and the laſt they dig them, then pick them out as carefully as they can, that little Seed may remain; and the fourth Year they plough the Ground, and ſow Barley, and the Produce is very good for ſome Years. Some Potatoes will remain and grow up without any Hurt to the Barley or Oats; and thoſe they dig and pick out, and the Ground remains good and arable ever after.

'Tis obſervable, that Shells do beſt in boggy Ground, where the Surface is Turf; Turf generally is nothing but the Product of Vegetables, ſuch as Graſs, Heath, *&c.* that being rotten, the Salt is waſhed away by the Water, and there remains only the earthy, and eſpecially the ſulphureous Parts of them, as appears from the Inflammability of Turf; now Shells being chiefly a Salt, it incorporates with the Sulphur of the Plants, and renders them fit for the Vegetation of new Plants.

And this appears further from this, that Shells that have been under the Salt Water are much better than ſuch as have been in the Earth, to dry at the Strands: Almoſt about the Bay of *Londonderry*, if you dig a Foot or two, it yields Shells, and whole Banks are made up of them; but theſe, tho' more intire than ſuch as are brought out of the Shell Iſland, are not ſo profitable for Manure.

I obſerved in a Place near *Newtown-Lamavady*, about two Miles from the Sea, a Bed of Shells, ſuch as lie on the Strand; the Place was cover'd with a Scurf of wet ſpouty Earth, about a Foot thick; the Country People uſed the Shells, but they were not reckon'd ſo good as thoſe that are found in the Sea or near it.

The Land about the Sea-ſide bears very indifferent Wheat, nor will the Shells do in that Particular, without ſome Dung; but I very much doubt, whether that be not due to the Ignorance of the Farmers, that generally underſtand nothing of Wheat.

Some Thouſands of Acres have been improved by the Shells, and that which formerly was not worth a Groat *per* Acre, is now worth four Shillings: They have in many Places thus improved the very Mountains, that before were very Turf Bogs. In theſe they meet with this Inconveniency, that if the Seaſon for Ploughing proves wet, their Horſes ſink ſo deep in the Soil, that they can't plough it, eſpecially after two or three Years.

They commonly made Lime of the Shells formerly, and ſome do ſo ſtill. I have not, that I remember, ſeen any ſuch Lime, but I underſtood that it bound very well, and I believe it is not ſo corroſive as Lime made of Stone; for I find, in the Hiſtory of *Ceylan*, that they make up their Land with Lime of Oyſter-Shells, and which I believe would be impracticable with Common Lime.

About 30 Years ago they made Lime of the Shells, and manur'd their Lands with it; but a poor Countryman, that, out of Lazineſs or Poverty, had not provided to make Lime, threw the Shells unburnt on his Land; his Crop prov'd as good as his Neighbours, and the ſecond and third Crop better, and all took the Hint, and have uſed them ſo ever ſince.

Where Shells are not to be procur'd, Sea-Rack or Sand ſupply the Want of them, but are not ſo good; Sea-Rack laſts but three Years, and Sand little longer.

'Tis certain, *Ireland* has been better inhabited than it is at preſent: Mountains that now are cover'd with Bogs, have formerly been plow'd; for when you dig five or ſix Feet deep, you diſcover a proper Soil for Vegetables, and find it plow'd into Ridges and Furrows. This is obſervable in the wild Mountains between *Ardmagh* and *Dundalk*, where the Redoubt is built, and likewiſe on the Mountains of *Altmore*: The ſame, as I am inform'd, has been obſerv'd in the Counties of *London-Derry*, and *Donegal*; a Plow was found in a very deep Bog in the latter, and a Hedge with Wattles ſtanding under a Bog that was five or ſix Feet deep above it. I have ſeen the Stump of a large Tree in a Bog, ten Feet deep, at *Caſtle-Forbes*; The trunk had been burnt, and ſome of the Cinders and Aſhes lay ſtill on the Stump. I have ſeen likewiſe large old Oaks grow on Land, that had the Remains of Ridges and Furrows: And I am told, that on the Top of a high Mountain in the North, there are yet remaining the Streets and Footſteps of a large Town; and indeed there are but few Places, which do not viſibly (when the Bog is remov'd) retain Marks of the Plow; which ſure muſt prove, that the Country was well inhabited. It's likely that the *Danes* firſt, and then the *Engliſh*, deſtroy'd the People; and the old Woods ſeem to thoſe that pretend to judge, to be about three or four hundred Years ſtanding, which was near the Time that *Courcey* and the *Engliſh* ſubdued the North of *Ireland*, and 'tis likely made Havock of the People, that remain'd after the *Danes* were beat out of *Ireland*.

Of the Manuring *of* Land *by* Sea-Sand *in* Devonſhire, *by Dr.* A. Bury. n. 316. p. 142.

II. The Burning of the Surface of the Land is ſo much practis'd in *Devonſhire*, that 'tis elſewhere known by the Name of *Devonſhiring*; but it is uſed only for bad Lands, and by worſe Huſbands, for it robs the Ground.

Salt quickens dead Land, and is uſed in the South Weſt Part of the Country, which would elſe be the barrenneſt, but is now the richeſt Part of it. They go as far as the Sea will permit them, at the loweſt Ebb, and take the Sand in Bags; and carry it on Horſeback 14 Miles into the Country, and ſpread it upon the Land, and thereby improve it both for Corn and Graſs. In other Parts they force their barren Land, by mingling the Earth with Lime, and caſting it upon the Ground.

In this they differ, that Crude and Single *Salt*, if ſtrew'd upon the Ground, does not improve, but corrode it; but *Lime*, tho' unmingled, betters it: But in this they agree, that they produce not Graſs fit for the Scythe, but for Paſture, ſhort and ſweet, and which grows all the Winter; ſo that their Sheep know not either Hay or Water, nor are their higheſt Grounds parch'd by the Sun in the hotteſt Summer. The beſt Way is, to mix theſe Male and Female Salts; for the Sea Salt is too luſty and active of itſelf; the Lime has a more Balſamic, but gentler Salt, and regularly join'd with the other, is thereby invigorated. How to mix thoſe two, *Glauber* thus directs: *Take* (ſays he) *Quick-Lime, let it ſlack by Time without Water; then take Salt and Water, mingle them together, and make them into Balls or Pieces, which you pleaſe; dry them as you do Bricks, then burn them for about two Hours; this Compoſt will enrich the pooreſt Land.*

Thoſe who are much devoted to Agriculture, ſhould chuſe ſuch a Situation for a Dwelling, as is beſt accommodated with Lime, Salt, and Coals; and if our Gentry underſtood this Huſbandry, they would ſo far free Salt from its Tax, as it ſhould be employ'd on Land, which is not intended to pay for it.

Obſervations relating to the Motion *of the* Sap *in* Vegetables, *by Mr.* R. Bradley. n. 349. p. 486.

III. It may in general be obſerv'd of *Plants*, that they are either *Terreſtrial*, *Amphibious*, or *Aquatic*; and ſo nearly do Vegetables agree with Animals in moſt Points, except Local Motion and its Conſequences, that from the Knowledge of the one we are reaſonably led to the Diſcovery of the other.

Thoſe Plants, which I call *Terreſtrial*, are ſuch as *Trees*, *Shrubs*, and *Herbs*, which grow only on the Land. Theſe like Land-Animals have Diverſities of Food, a Method of Generating, and certain Periods of Life.

Of the *Amphibious* Race, which live on Land as well as in the Waters, are the *Willows*, *Ruſhes*, *Mints*, &c. Theſe are not unlike in many Reſpects to the *Otter*, *Tortoiſe*, *Frog*, &c.

The *Aquatics*, whether of *Lakes*, *Rivers*, or the *Sea*, are very numerous: Theſe may be compar'd with the *Fiſh-kind*, and will not live out of their proper Elements. In *Freſh Waters* are the *Water-Lillies*, *Plantains*, &c. and in the *Sea*, *Corals*, *Fuci*, &c.

Plants ſeem to poſſeſs only the next Degree of Life below the moſt ſtupid *Animal*; or where Animal Life leaves off, the Vegetable Life ſeems to begin.

The Seaſons of Motion in *Plants* are the ſame with thoſe of *Animals*, which ſleep during the Winter. An Artificial Heat will give Motion to either of theſe in the coldeſt Time.

The common Opinions relating to the *Sap's* Motion, are as follows; Firſt, the *Sap* does not riſe by the *Pith*; becauſe ſome have obſerv'd the Trunks of large Trees to be without that Part, and yet the ſame Trees have continued to put forth Fruit and Branches on their Tops. I have obſerv'd, that the *Pith* is not found in thoſe Branches of a Tree, which exceed two or three Years Growth; and it is certain, that the *Pith*, which is in a Branch of this Year, will (the greateſt Part of it) be diſtributed into thoſe Boughs, which form themſelves the next Seaſon.

It is ſaid by ſome, that the Tree does not receive its Nouriſhment by the *Bark*, for that Trees having loſt that Part, will ſtill continue their Growth. Others tell us, that if the *Bark* be cut away round the Trunk of a Tree, it will preſently die. Theſe various Opinions ſeem to have been ſet on Foot without extraordinary Conſideration, upon the Belief, that a Tree has but one *Bark*; whereas, upon Examination with the Microſcope, we find four diſtinct Coverings to each Branch, without the woody Parts. The two outermoſt *Barks* may be taken from a Tree without any great Damage, but the other two, which lie nearer the Wood, being ſtripp'd off, will kill the Tree.

Some affirm, that the *Sap* doth neither riſe nor fall in the woody Part of the Tree, becauſe they have not been able to diſcern any *Sap* to iſſue out of that Part when a Branch has been cut. The Microſcope plainly ſhews us the Veſſels in the Wood, through which the *Sap* riſeth from the Root; but as theſe Tubes are not large enough to admit into them any Thing more groſs than Vapour, ſo they have not been eſteem'd to be of any great Uſe. The Explanation of *Figure* 47. will in ſome meaſure diſcover the Office of theſe and of ſuch other Parts of a *Plant*, as are ſeverally deſign'd for the Growth of Vegetables; but let us firſt enquire a little into the Nature of the *Root*.

The *Root* of a Tree is chiefly compoſed of a *Parenchyma*, more groſs than that in the Stem or Body of the Tree; it has likewiſe Veſſels and a Covering. The Root, that is, the principal Part of it, receives into it ſuch Juices of the Earth, as are proper for it, and no other. Somewhat like a Wick of Cotton, which having been impregnated with Oil, will only admit Oil into it. This Proviſion being made in the *Stomach* of the *Plant* (as I call it) chiefly in the Autumn Months, the Tree is prepared for Germination, ſo ſoon as the Earth is ſufficiently warm'd, either by the Sun's Beams, or an artificial Heat, ſuch as Horſe-dung, Bran and Water, or other ſuch like Ferments, Theſe Heats raiſe into Vapour the Juices contained in the Root, and by that Means cauſe Vegetation.

Fig. 47. is part of the Branch of an *Apple Tree* made in *May* 1715, and cut in *April* 1716. It was cut in Figure of a half Cylinder, the length ſomewhat more than the Diameter, which was about a Quarter of an Inch. This being magnified with one of *Campani*'s Microſcopes, diſcovers the following Parts, *viz.* Fig. 47.

1, 2, 3, 4, 5, 6, 7, Are Capillary Veſſels, which run longitudinally through the Branch; in the ligneous part, which was made in the Year 1715. Through theſe Tubes, the Steam riſeth from the Root, the Strength of which is well explain'd by the Engine for raiſing Water by Fire, invented by the late Captain *Savery*.

From A to B, we may view Veſſels of the ſame ſort, made at the ſame Time.

8, 9, Are Veſſels of the ſame Uſe with the former, now forming themſelves for the Uſe of the Year 1716.

By this Means the Diameter of the Branch is increas'd, and additional Nouriſhment ſuffer'd to paſs into thoſe Buds, which are to make new Branches. Theſe are made out of the fourth or innermoſt Bark, mark'd C, C.

The Mouths of the Capillary Tubes of the Years 1715, and 1716, are D, E. The Vapour which riſeth from the Root, is continued in theſe Veſſels, to the Extremities of the Branches, where it meets with Parts (not here deſcrib'd) like to *Glands*; which *Glands*, if we may ſo call them, are likewiſe found at every Knot or Joint. At theſe Places, the Vapour coming near the Air, is condenſed, and returns between the Barks, by means of its own Weight, down F, G, H, leaving in each Bark mark'd I, K, L, ſuch Juices as each of them naturally is inclin'd to ſeparate from it; till at laſt, the more oily part paſſing to the Root, may lengthen the *Fibres* thereof, as Icicles are lengthened; and by its oleous Particles, preſerve them from rotting by the Wet. The parts which compoſe the ſeveral Barks, are *Parenchymous* or *Spungy*.

The firſt mark'd M, is of a cloſer Texture than the ſecond N, and the ſecond cloſer than the third O, and ſo on till theſe parenchymous parts are interwoven with the longitudinal Wood-Veſſels, where they are ſomewhat conſtrain'd; till they come to make the Pith, mark'd P. Then they are much larger than in any other part of the Tree; and by what I have obſerv'd, ſeem to contain a more finiſh'd Juice than the reſt, and may well enough be ſtiled the *Medulla*.

We may note, that when the fourth or innermoſt Bark C, has once compleated its Sap-Veſſels, and is firmly join'd to the wooden part, then the third Bark O, takes its place for the ſucceeding Year; and ſo the reſt, except that the firſt, mark'd M, ſplits and divides itſelf, to ſupply the place of the ſecond.

The following Enquiry I recommend to the Curious, *viz.* If the ſeveral Barks, having different Texture of parts, admit into each ſeparate and different Juices from the reſt; whether thoſe Juices may not be of very different Virtues; the firſt more *Aſtringent* than the others, the ſecond perhaps *Emetick*; and the third *Cathartick*.

Some new Obſervations on the Parts and Uſe of the Flower *in* Plants, *by Mr.* S. Moreland. n. 287. p. 1474.

IV. The nice and curious Texture of the *Flower* in Plants, and its Furniture, has employ'd the Enquiries of many Learned Men. But ſince theſe Searchers into the Hiſtory and Operations of Nature, ſeem not ſo ſucceſsfully to have reach'd her Deſign in this Caſe, as in many others, I ſhall attempt to account for the Fabric and Uſe of theſe Parts, and to make the Propagation of Vegetables more intelligible, whereby the Ways of Nature will appear more harmonious, and of a piece.

It has been long ago obſerv'd, that there is in every particular Seed a Seminal Plant, conveniently lodg'd between the two Lobes, which conſtitute the Bulk of the Seed, and are deſign'd for the firſt Nouriſhment of this tender Plant.

Dr. *Grew* is the only Author I can find, who has obſerv'd that the *Farina* (or fine Powder which is at its proper Seaſon ſhed out of thoſe *Thecæ* or *Apices Seminiformes*, which grow at the Top of the *Stamina*) doth ſome Way perform the Office of Male Sperm. But herein I think he falls ſhort, in that he ſuppoſes them only to drop upon the outſide of the *Uterus* or *Vaſculum Seminale*, and to impregnate the included Seed by ſome ſpirituous Emanations or energetical Impreſs.

That which is now ſubjected to Enquiry, is, whether it be not more proper to ſuppoſe, that the Seeds which come up in their proper *Involucra*, are at firſt like unimpregnated *Ova* of Animals; that this *Farina* is a *Congeries* of Seminal Plants, one of which muſt be convey'd into every *Ovum* before it can become prolifick; that the *Stylus* in Mr. *Ray*'s Language, the upper part of the *Piſtillum* in Mr. *Tournefort*'s, is a Tube deſign'd to convey theſe Seminal Plants into their Neſt in the *Ova*; that there is ſo vaſt a Proviſion made, becauſe of the Odds there are, whether one of ſo many ſhall ever find its Way into, and through ſo narrow a Conveyance.

To make this Suppoſition the more credible, I ſhall lay down the Obſervations I have made upon the Situation of theſe *Stamina* and the *Stylus* in ſome few Species of Plants.

Firſt, in the *Corona Imperialis*, where the *Uterus* or *Vaſculum ſeminale* of the Plant ſtands upon the Center of the Flower, and from the Top of this ariſeth the *Stylus*, the *Vaſculum ſeminale* and *Stylus* together repreſenting a *Piſtillum*. Round this are planted ſix *Stamina*, upon the Ends of each of theſe are *Apices*, ſo artfully fixt, that they turn every Way with the leaſt Wind, being in Height almoſt exactly equal to the *Stylus* about which they play, and which in this Plant is manifeſtly open at the Top, as it is hollow all the Way. To which we muſt add, that upon the Top of the *Stylus* there is a ſort of *Tuft*, conſiſting of pinguid *Villi*, which I imagine to be plac'd there, to catch and detain the *Farina*, as it flies out of its *Thecæ*. From hence I ſuppoſe the Rain either waſhes it, or the Wind ſhakes it down the Tube, till it reach the *Vaſculum ſeminale*.

In *Capri-folium*, or *Honey-ſuckle*, there riſes a *Stylus* from the rudiments of a Berry, into which it is inſerted to the Top of the *Monopetalous* Flower, from the Middle of which Flower, are ſent forth ſeveral *Stamina*, that ſhed their *Farina* out of the Caſes upon the Orifice of the *Stylus*, which in this Plant is villous or tufted, upon the ſame Account as the former.

In *Allium* or *common Garlick*, there ariſes a *Tricoccous Uterus*, or Seed-Veſſel, in the Center of which is inſerted a ſhort *Stylus*, not reaching ſo high as the *Apices*, which thus over-topping it, have the Opportunity of ſhedding their Globules into its Orifice more eaſily. For which Reaſon I can diſcern no Tuft upon this (as in the former) to enſure their Entrance, that being provided for by its Situation juſt under them.

I ſhall now make ſuch Reaſonings or Reflections as the foregoing Account doth ſuggeſt, and will ſupport.

Nothing can be more natural than to conclude, that where a fine *Powder* is curiouſly prepared, carefully repoſited, and ſhed abroad at a peculiar Seaſon, where there is a Tube ſo planted, as to be fit to receive it, and ſuch Care in diſpoſing this Tube, that where it doth not lie directly under the Caſes that ſhed the Powder, it hath a particular *Apparatus* at the End to enſure its Entrance: Nothing can be more genuinely deduced from any Premiſes, than from this it may, that this *Powder* or ſome of it was deſigned to enter this Tube. If theſe *Stamina* had been only excretory Ducts, as has been hitherto ſuppoſed, to ſeparate the groſſer Parts, and leave the Juice deſigned for the Nouriſhment of the Seed more reſerved, what need was there to lodge theſe Excrements in ſuch curious Repoſitories? They would have been conveyed any where, rather than where there was ſo much Danger of their dropping into the *Seed Veſſel* again, as they are here.

Again, the *Tube* over the Mouth of which they are ſhed, and into which they enter, leads always directly into the *Seed Veſſel*.

To which we muſt add, that the *Tube* always begins to die, when theſe *Thecæ* are empty'd of their Contents; if they laſt any longer, it is only whilſt the *Globules* which enter at their Orifice, may be ſuppoſed to have finiſhed their Paſſage. Now can we well expect a more convincing Proof of theſe *Tubes* being deſigned to convey theſe *Globules*, than that they wither when there are not more *Globules* to convey?

If I could ſhow that the *Ova*, or unimpregnated Seed, are ever to be obſerved without this *Seminal Plant*, the Proof would ariſe to a Demonſtration; but having not been ſo happy as to diſcern this, I recommend the Enquiry to thoſe who are Maſters of the beſt Microſcopes. Though, in the mean Time, I have made ſome Steps towards a Proof of this Sort, and have met with ſome ſuch Hints as make me not deſpair of being able to do it: For, not to inſiſt upon this, that the *Seminal Plant* always lies in that Part of the Seed, which is neareſt to the Inſertion of this *Stylus*, or ſome Propagation of it into the *Seed Veſſel*; I have diſcovered in *Beans*, and *Peaſe*, and *Phaſeoli*, juſt under one End of that we call the *Eye*, a manifeſt Perforation (diſcernible by the groſſer ſort of Magnifying Glaſſes) which leads directly to the *Seminal Plant*, and at which I ſuppoſe the *Seminal Plant* did enter; and

I am apt to think, that the Beans or Peaſe which do not thrive, will be found deſtitute of it.

I ſhall now deſcribe ſome other Plants, whereby it will appear, that there is a particular Care always exerciſed to convey this Powder into a *Tube*, which may convey it to the *Ova*. Now in *Leguminous* Plants, if we carefully take off the *Petala* of the Flower, we ſhall diſcover the *Pod* or *Siliqua* cloſely covered with an involving Membrane, which about the Top ſeparates into many *Stamina*, each fraught with its Quantity of *Farina*, and theſe *Stamina* are cloſe bound upon the *Bruſh*, which is obſervable at the End of that *Tube*, which here alſo leads directly to the *Pod*: It ſtands not upright indeed, but ſo bended, as to make near a right Angle with it.

In *Roſes* there ſtands a *Column*, conſiſting of many *Tubes* cloſely clung together, though eaſily ſeparable, each leading to their particular Cell, the *Stamina* in a great Number planted all round about. In *Tithymalus*, or *Spurge*, there riſes a *Tricoccous* Veſſel, that whilſt it is ſmall and not eaſily diſcernible, lies at the Bottom till impregnated, but afterwards grows up, and ſtands ſo high upon a tall *Pedicle* of its own, as would incline one to think that there were to be no Communication betwixt this and the *Apices*, which he ſees dying below.

In *Straw-berries* and *Raſp-berries*, the Hairs which grew upon the ripe Fruit (which I ſuppoſe may be ſurprizing to ſome) are ſo many *Tubes* leading each to their particular Seed, and therefore we may obſerve, that in the firſt opening of the Flower, there ſtands a Ring of *Stamina* within the *Petala*, and the whole inward *Area* appears like a little Wood of theſe Hairs or Pulp, which when they have received and conveyed their *Globules*, the Seeds ſwell and riſe in a carneous Pulp.

I have obſerved, and can deduce the Contrivance and Adminiſtration of the Parts in all the Plants I have obſerved, and I doubt not but others may be able to perfect what I have rudely hinted; and that from this Theory many Corollaries may be derived, which will let in Light into many Parts of Natural Philoſophy. I ſhall at preſent only ſuggeſt, that hence one would conclude, that the *Petala* of the Flower were rather deſigned to ſever ſuperfluous Juices, from what was left to aſcend in the *Stamina*, than the *Stamina* to perform this Office, either for them, or the unimpregnated *Semina*; and obſerve the Analogy between *Animal* and *Vegetable* Generation, as far as was neceſſary, there ſhould be an Agreement between them.

The Explication of the Figures.] *Fig.* 48. repreſents a *yellow Lilly*. *A* the Top of the *Piſtillum* or Tube, at which the *Seminal Plants* are ſuppoſed to enter, and through which they are conveyed to the unimpregnated *Seed* in the *Seed Veſſel*. Fig. 48.

b, *b*, *b*, *b*, *b*, *b*, the *Apices Seminiformes*, which when they are ripe open, and ſhed that *Powder* which enters the *Tube* at *A*.

C, the Place of the *Seed Veſſel* at the Bottom of the *Tube*, the Seed-Veſſel itſelf being concealed under the Leaf in this Draught.

Fig. 49. *Fig.* 49. *D*, the *Siliqua* in a Flower of the *Pea-kind.*

E, the *Tube* which ariſes from the *Siliqua*, and conveys the *Plants* to it.

F, the *Membranous* Coat that involves the *Siliqua* laid open.

g, g, g, g, g, g, the *Apices*, which, before the Membranous Tegument is laid open, appear to riſe from its Edges, and by the *Petala* of the Flower, are kept cloſe upon the *Orifice* of the *Tube*, that they may conveniently ſhed their *Farina* into it.

Fig. 50. *Fig.* 50. A *French-Bean* repreſented ſidwiſe.

Fig. 51. *Fig.* 51. The ſame opened.

h, The Seminal Plant.

i, A Perforation, at which, 'tis ſuppoſed, the Seminal Plant firſt enter'd.

Of the Quick Propagation *of* Moldineſs, *&c. in a* Melon, *by Mr.* R. Bradley, n. 349. p. 490.

V. I had lately a large Melon-Fruit, which I ſplit lengthways thro' the Middle, in order to obſerve the Veſſels which compoſed the Membrane or Tunic of each Ovary; but not continuing the Work I had begun, I laid by one half of the Melon, to be examined when I might have more Leiſure.

At the End of four Days, I found ſeveral Spots of Moldineſs began to appear on the fleſhy Part of the Fruit, ſomewhat Green towards the Rind; and of a paler Colour towards the Middle of the Fruit. Theſe Spots grew larger every Hour, for the Space of five Days; at which Time the whole Fruit was quite covered.

This ſurprizing Vegetation made me curious to examine if there was any Difference between thoſe Parts which were Green and the others, beſides their Colour. The firſt being ſeen with the Microſcope, appear'd to be a *Fungus*, whoſe Cap was filled with little Seeds, to the Number of about five Hundred; which ſhed themſelves in two Minutes after they had been in the Glaſſes. Fig. 52.

The other Sort had many Graſs-like Leaves, among which appeared ſome Stalks with Fruit on their Top, each Plant might well enough be compared to a ſort of *Bull-Ruſh*. They had their Seed in great Quantities, which I believe were not longer than three Hours before they began to vegetate; and it was about ſix Hours more, before the Plants were wholly perfected: For, about ſeven of the Clock one Morning, I found three Plants at ſome Diſtance from any others; and about four the ſame Day, I could diſcern above five Hundred more growing in a Cluſter with them, which I ſuppoſed were Seedling Plants of that Day. The Seed of all theſe were then ripe and falling. Fig. 53.

When the whole Fruit had been thus cover'd with Mold for ſix Days, this vegetable Quality began to abate, and was entirely gone in two Days more. Then was the Fruit putrified, and its fleſhy Parts now yielded no more than a ſtinking Water, which began to have a gentle Motion on its Surface, that continued for two Days without any other Appearance. I found then ſeveral ſmall Maggots to move in it, which grew for the Space of ſix Days; after which they laid themſelves up in Fig. 54.

in their Bags. Thus they remain'd for two Days more without Motion, and then came forth in the Shape of Flies. The Water at that Time was all gone, and there remained no more of the Fruit than the Seeds, the Veſſels which compoſed the Tunics of the Ovaries, the outward Rind, and the Excrement of the Maggots; all which together weighed about an Ounce. So that there was loſt of the firſt Weight of the Fruit when it was cut, about twenty Ounces.

Fig. 55.

We may judge from this, and other Caſes of the like Nature, how much vegetable Life is dependent on Fermentation, and animal Life on Putrefaction.

Of the Huſbandry *of* Canary Seed. *by Mr.* E. Teniſon. n. 337. p. 91.

VI. To prepare Land for *Canary Seed*, let it be broke up ſome Time in *April*, and ploughed again about *Midſummer*, and ploughed again in *Auguſt*, that by frequent Tillage the Weeds may be burnt up, and deſtroyed. Plough the laſt Time about the latter End of *February*, or the Beginning of *March*, if the Seaſon proves dry; if not, you had beſt wait for a dry Seaſon; for in ſuch a Seaſon only will the Ground be fit to receive the Seed. With a Hoe, (that has a Bit about the Bigneſs of an Onion-Hoe) you muſt from Time to Time carefully cut up the Weeds. If they are not kept entirely under, much of the Seed will be loſt for Want of ripening. In very good Land half a Buſhel of Seed will be enough to ſow an Acre. It will thrive beſt upon a ſtiff Clay: It will grow upon any ſort of Loamy Land, that is rich enough to bear Hemp. If you apprehend that the Land is not ſufficiently ſtrong, you will do well to allow from half a Buſhel to ſeven Gallons of Seed to ſow an Acre with.

The Seed is ripe ſooner or later, according as the Spring affords you an early or late Seaſon of ſowing it. In ſome Summers 'tis cut in *Auguſt*, but the moſt uſual Time is after Wheat-Harveſt. When it is cut it muſt in moſt Years lie five or ſix Days in ſwarth, and then be turn'd, and lie till one Side is dryed and rotted as much as the other, which may be about four or five Days longer. The certain Number of Days cannot be fixed, becauſe they muſt be more or leſs, according as the Weather proves fair or rainy.

The Reaſon of its lying ſo long in ſwarth is, that the lower Heads of the Seed (being expoſed to the Air, Wind and Sun) may the better perfect their Ripeneſs, and the Graſs and Weeds that ſprung up with the Stalks be thoroughly withered, and the Ears or Heads well and ſufficiently rotted, and that the Seed upon threſhing may come out clean.

The Produce upon Land that is very good, is about ſix Quarters *per* Acre.

If the Land be but indifferent, or if the Weeds be not kept under, then from four to five Quarters upon an Acre, is as much as you can expect.

The Price of Seed is, from two Pounds to ſix Pounds *per* Quarter; but the moſt uſual Price is from forty Shillings to three Pounds.

It is difficult to threſh. So much of the Seed as, after threſhing, is beaten out (as ſoon as 'tis fanned) is to be run through a Wire-Sieve (ſuch as is uſed to ſeparate Cockle from Corn) and the Huſks of every ſifting, that will not paſs through the Sieve, are to be thrown by in a Heap to be threſhed over again.

The ordinary Price for threſhing is Five Shillings, but in ſome Years the Threſher has Six Sillings *per* Quarter.

Experiments *on* Vegetation, *by Mr.* Abr. de la Pryme. n. 281. p. 1214.

VII. Some have made Experiments of the Meliorating, Fertilizing, and Multiplying of Grain, by ſteeping them in divers Liquors. *Digby* ſomewhere mentions, a Plant of Barley all riſing from one Corn, that by Steeping and Watering with Salt Petre diſſolved in Water, brought forth 249 Stalks, and above 18000 Grains. And the laſt Edition of *Cambden* mentions a Thing very obſervable, that the Corn ſown in a Field in *Cornwall*, after a great Battle in the Civil War Time, brought forth four or five Ears on every Stalk. I have try'd ſome ſuch like Experiments on ſeveral Grains, and though the Encreaſe was not ſuch as I expected, I communicate them to you.

On the 22*d* of *March*, 1699, I laid to ſteep a Pea, a Barley-Corn, and a Wheat-Corn in Brimſtone-Water.

A Pea, a Wheat, a Barley, and an Oat-Corn, in Allum-Water, and the ſame in an old Diſſolution of Salt of Tartar, in the *Caput Mortuum* of *Sal Armoniac* diſſolved in Urine, in a Diſſolution of the Salt of Walls, in a Diſſolution of Salt-Petre, in a Diſſolution of *Noſtoc* or Star-Gelly, and in Urine.

I ſteeped them thus five Days and five Nights, and ſet them in a Garden in a good Soil, againſt a North Wall full in the Sun, on the 27*th* of the ſame Month after a rainy Night, with a Pea, a Wheat, a Barley, and an Oat Corn unſteep'd.

Upon the 10*th* of *April* following, I found that ſome were juſt come up, ſome not.

The Pea, the Barley, and the Wheat ſteeped in Brimſtone-Water came all up together.

The Pea ſteeped in Allum-Water was very big and ſwelled, but not ſo much as ſprouted, but the Barley, Wheat, and Oat above Ground.

The Pea ſteeped in the old Solution of Salt of Tartar, was half come up, the Wheat ſcarce ſprouted, but the Barley and Oat quite up.

The Pea, the Wheat, the Barley, and the Oat ſteep'd in the *Caput Mortuum* of *Sal Armoniac* diſſolv'd in Urine were all up together; as were alſo the next Row, that were ſteep'd in the Solution of Salt of Walls.

The Pea and Wheat ſteep'd in the Diſſolution of Salt-Petre were about half up, but the Barley and Oat quite up.

Thoſe which were ſteep'd in *Noſtoc*, were none of them come up, nor ſcarce ſprouted.

The Barley and Oat ſteep'd in Urine, were come up, but the Pea and Wheat ſcarce ſprouted.

And, to my Surprize, the Pea, Wheat, Barley, and Oat, that were not at all ſteep'd, were all of them as ſoon up as any of the former, except only the Wheat, which was about half up.

I ſet them all about a Finger deep in the Ground, and there was all the Time of their Growth very fine Weather.

From all which I ſuppoſe, that Allum-Water is againſt the Nature of Peas, and retards their Growth, but agrees well enough with Wheat, Barley, and Oats.

That the Solution of Salt of Tartar is not friendly to the Nature either of Peas or Wheat, but agreeable to the Nature of Oats and Barley.

That the Water of Salt-Petre had not any of the great Power or Virtue that I ſuſpected, *&c.*

And that theſe Steepings did not further any of the ſaid Grains in their Growth and Coming, but plainly retarded ſome or moſt of them.

Then I digg'd all of them up, but three Spires of Barley, which I let ſtand about a Foot and a half, or two Feet, from one another; which grew and increaſed ſo exceedingly, that they had ſixty, ſixty-five, and ſixty-ſeven Stalks a-piece, from their ſingle Grain and Root, with every one an Ear on, and about forty or ſomewhat more Corns a-piece in them; which Increaſe proceeded not ſo much perhaps from the Grain having been ſteep'd in any Liquors, as from the Fertility and Goodneſs of the Soil, and their competent Diſtance one from another. I obſerved that new Shoots continually ſtruck up from the Root; and that as in the *Eaſt* and *Weſt-Indies*, there are Trees that always bear Bloſſoms and Flowers, green and ripe Fruit at the ſame Time, ſo that here, if the invigorating Heat of the Sun had not been cool'd and weaken'd by the Approach of the Winter-Seaſon, there would have been continually new, ripe Corn, and empty Ears, on the ſame Root.

Of the Great *and Speedy* Vegetation *of* Turnips. *Communicated by Dr.* J. T. Deſaguliers. n. 360. p. 974.

VIII. At *Sutton-Coldfield* in *Warwickſhire*, a peaty Ground near a Pool (of which it was formerly a Part) was ſown with *Turnip-Seed* on the 2d Day of *July* 1702. In leſs than three Days Time the Turnips were ſeen above Ground. At three Weeks End the Roots were in Bigneſs equal to Walnuts. Within leſs than five Weeks after the Sowing, the Gardener drew great Quantities of Turnips to ſell, they then being as big as large Apples. At the End of ſix Weeks, *viz.* on the 12*th* Day of *Auguſt*, a large Turnip was plucked up (though probably not ſo big as ſeveral others then growing upon the ſame Ground) which, together with its Top and long deſcending Part of the Root, weighed above two Pounds and fourteen Ounces. At the ſame Time alſo was weighed an Ounce of the ſame Sort of Turnip-Seed, that the Gardener had ſown his Ground with; and afterwards a thouſand of the Grains were counted ſingly out of the Ounce ſo weighed; and the reſt of the Ounce was divided into Heaps, as near as could be gueſſed, equal to the 1000 Seeds firſt ſevered and laid together: And it was found, that the whole Ounce contained above 14600 ſingle Grains; which number multiplied by 46 (*viz.* the Number of Ounces that the Turnip weighed) produced 671600, *viz.* the Number of ſingle Grains of Seed required to equal the Weight of the Turnip. From whence may be gathered, that (upon Suppoſition that the Increaſe of the Turnip was all along uniform and equal, from the Time it was ſown, till it was pluck'd up) the Grain of Seed which it ſprung from, weighing when it was ſown but $\frac{1}{14600}$ of an Ounce, was increas'd in Weight according to the following Proportions, *viz.*

In ſix Weeks Time	671600	Times its own Weight.
Every Week	111933 $\frac{1}{3}$	
Every Day	15990 $\frac{1}{2}$	
Every Hour	666 $\frac{1}{4}$	
Every Minute of an Hour	11	

Some Days after another Ounce of the ſame Sort of Seed was exactly weighed, and the Grains were found to be in Number 14673.

Another Turnip of the ſame Crop was pluck'd up on the 21*ſt* of *October*, and was found to weigh above 10 Pounds and a half, which unuſual and wonderful Bulk it acquir'd (it being ſuppoſed as above that the Growth was all alike) by increaſing the Weight of the Seed it was raiſed from, 15 Times in every Minute of an Hour, from the ſowing to the drawing of it.

The Gardener neglected to thin his Turnips in due Time, elſe probably their Growth had been more conſiderable.

At another Time, in two other Sorts of Turnip-Seed, it was found by counting, that an Ounce of one Sort contained 14702 Grains; and an Ounce of the other Sort no fewer than 14905 Grains.

It is credibly reported, that of late Years Turnips have been pretty frequently found growing in ſeveral Counties of this Kingdom, that have weighed above twice as much; one of which was ſeen at *Birmingham* about the Year 1710.

Of the Culture *of* Tobacco *in* Ceylan, *by* Mr. Strachan. n. 279. p. 1164.

IX. There are two Sorts of Tobacco, both which, they call *Dunkol*; the Signification is a Smoaking-Leaf; for *Dun* is Smoak, *Kol* a Leaf, the one they call *Hingele Dunkol*, or *Singele Dunkol*, for they make no Diſtinction of *H* and *S*; the other is called *Dunkol Kapada*, which Word *Kapada* ſignifies gelding, and is derived from the *Portugueſe*; which Tobacco is very intoxicating, and much ſtronger than the former; it is the ſame Plant, the Difference is only that *Singeleſe* Tobacco has little attendance,

tendance, upon the other a great deal of Pains is taken, until it be fit for Uſe; and it is done after the following Manner:

They clear a little piece of Ground, in which they ſow the Seed of Tobacco, as the Gardeners here ſow Parſley and Coleworts; againſt the Time that this is ready for tranſplanting, they chooſe a piece of Ground, which they hedge about; when the Buffalo's begin to chew the Cud, they are put within this Hedge-Ground, and let ſtand until they have done, and this they continue Day and Night, until the Ground be ſufficiently dunged; then the Ground is tilled with a Spade, in Form of a Pick-ax, ſuch as Carpenters uſe when they ſmooth Planks, by hoeing the Ground, and turning the ſame, and mixing the Dung among the Earth; when they have made the Ground ſmooth, they remove the Plants out of the Bed, wherein they were ſown, and ſet them in this Ground, about a Foot Diſtance one from another, and then they grow up almoſt like a Dock; when the Stem has got 15 Leaves, they cut off all the Tops of the Plants; if they deſire not to have the Tobacco to be very ſtrong, they let it grow until it have 18 or 20; if they will have it ſtronger, they top it when it has got 10 or 12 Leaves, not counting the 3 or 4 loweſt Leaves, which are neareſt the Ground, becauſe they never grow ſo big and good, as thoſe above them. Thus the Moiſture of the Ground being hinder'd from waſting in more Leaves, Flowers and Seed, all the ſaid Moiſture enters into the Leaves remaining, ſo that theſe Leaves will be 4 or 5 Times larger, fuller of Fatneſs, Strength and Virtue, than the Tobacco which is not ordered after this Manner. Now the Moiſture aſcending from the Root, being conſtrained within the Bounds of theſe Leaves, forces its Way betwixt the Stem and Leaves remaining, and ſends forth young Sprouts, and would grow forth in Branches, if no Care were taken to hinder. Therefore every 3 or 4 Days they go through all the Stems, and break off theſe Buds whenever they ſpring forth, and this they continue, until theſe Leaves be ripe (which takes as much Time as the *Singele* Tobacco does, which gets Flowers and ripe Seed, and then begins to wither and ſpoil, if no Uſe be made of it) which is known by the Thickneſs and Firmneſs.

Then before the Leaf begins to wither, and is green, they cut down the Stem together with the Leaves, and do bring them into their Houſes, and lay them in a Heap; and thus the Leaves will begin to ferment, turn hot, and ſweat, then when the Leaves begin to ſweat, they turn the innermoſt outmoſt, that they may eaſily ferment; otherwiſe the innermoſt would ferment too much, ſpoil, and rot: Thus the longer they lie in a Heap together, the Tobacco turns the more dark of Colour. When they think it has ſweat enough, they hang it aſunder upon Cords, till the Leaves be dry, then they ſeparate the Leaves from the Stalks, and lay them up in Bundles together, until they have Uſe for them.

Now the other Tobacco, called *Singele Dunkol*, is only ſown, and then planted, and has Liberty to grow, to ſhoot out, flower, and ſeed; thus all ripen together: Then it is cut down and caſt together in a Heap;

ſome will ferment too much, and rot, others will ferment not at all, and will remain green, although it be dry, and will have a ſmell of Hay or dry Graſs. The Soldiers, who delight to ſmoak a big Pipe full, and that frequently in one Day, do ſmoak this common ſort, ſome will mix ſome of the *Kapada* among it; the *Cingualeſes*, who ſmoak not ſo much at once, neither ſo frequently, do take a piece of the *Kapada*, and roll it together, then roll a piece of dry Leaf of the *Wattakan* Trees about this, and kindle it at one End, and ſuck at the other, until it be conſumed. Some do chew it among Betle, taking but very little at once.

Of a Tartarian Plant *called* Gin-ſeng, *&c. by Father* Jartoux, *taken from the Tenth Vol. of* Letters *of the Miſſionary* Jeſuits. n. 337. p. 237.

X. The Map of *Tartary*, which we made by Order of the Emperor of *China*, gave us an Opportunity of ſeeing the famous Plant *Gin-ſeng* or *Nin-zin*, ſo much eſteem'd in *China*, and ſo little known in *Europe*. Towards the End of *July* 1709, we arrived at a Village, not above four ſmall Leagues diſtant from the Kingdom of *Corea*, which is inhabited by thoſe *Tartars* called *Calca tatze*. One of theſe *Tartars* went and found upon the neighbouring Mountains four Plants of the *Gin-ſeng*, which he brought us entire in a Baſket. I took one of them, and deſigned it, as well as I could.

The moſt eminent Phyſicians in *China* have writ whole Volumes upon the Virtues and Qualities of this Plant, and make it an Ingredient in almoſt all Remedies which they give to their chief Nobility; for it is of too high a Price for the common People. They affirm, that it is a ſovereign Remedy for all Weakneſſes occaſion'd by exceſſive Fatigues either of Body or Mind; that it diſſolves pituitous Humours; that it cures Weakneſs of the Lungs, and the Pleuriſy; that it ſtops Vomitings; that it ſtrengthens the Stomach, and helps the Appetite; that it diſperſes Fumes or Vapours; that it fortifies the Breaſt, and is a Remedy for ſhort and weak Breathing; that it ſtrengthens the Vital Spirits, and increaſes Lymph in the Blood: In ſhort, that it is good againſt Dizzineſs of the Head, and Dimneſs of Sight, and that it prolongs Life in old Age.

No Body can imagine that the *Chineſe* and *Tartars* would ſet ſo high a Value upon this Root, if it did not conſtantly produce a good Effect. Thoſe that are in Health often make uſe of it to render themſelves more vigorous and ſtrong: And I am perſuaded, that it would prove an excellent Medicine in the Hands of any *European* who underſtands Pharmacy, if he had but a ſufficient Quantity of it, to make ſuch Trials as are neceſſary, to examine the Nature of it chymically, and to apply it in a proper Quantity, according to the Nature of the Diſeaſe for which it may be beneficial.

It is certain, that it ſubtilizes, increaſes the Motion of, and warms the Blood; that it helps Digeſtion, and invigorates in a very ſenſible manner. After I had deſigned the Root, I obſerved the State of my Pulſe, and then took half of the Root, raw as it was, and unprepar'd: In an Hour after, I found my Pulſe much fuller and quicker; I had an Appetite,

tite, and found my ſelf much more vigorous, and could bear Labour much better and eaſier than before.

But I did not rely on this Trial alone, imagining that this Alteration might proceed from the Reſt that we had that Day: But four Days after, finding my ſelf ſo fatigued and weary that I could ſcarce ſit on Horſeback, a *Mandarin*, who was in Company with us, perceiving it, gave me one of theſe Roots: I took half of it immediately, and an Hour after I was not the leaſt ſenſible of any Wearineſs. I have often made Uſe of it ſince, and always with the ſame Succeſs. I have obſerved alſo, that the green Leaves, and eſpecially the fibrous Part of them chewed, would produce nearly the ſame Effect.

The *Tartars* often bring us the Leaves of *Gin-ſeng* inſtead of *Tea*; and I always find my ſelf ſo well afterwards, that I ſhould readily prefer them before the beſt Tea. Their Decoction is of a grateful Colour; and when one has taken it twice or thrice, its Taſte and Smell become very pleaſant.

As for the Root of this Plant, it is neceſſary to boil it a little more than Tea, to allow Time for extracting its Virtue; as is practiſed by the *Chineſe*, when they give it to ſick Perſons, on which Occaſion they ſeldom uſe more than the fifth Part of an Ounce of the dry'd Root. But as for thoſe that are in Health, and take it only for Prevention, or ſome ſlight Indiſpoſition, I would adviſe them not to make leſs than ten Doſes of an Ounce, and not to take of it every Day. It is prepared in this Manner: The Root is to be cut into thin Slices, and put into an Earthen Pot well glazed, and filled with about a Quarter of a Pint of Water *Paris* Meaſure: The Pot muſt be well covered, and ſet to boil over a gentle Fire; and when the Water is conſumed to the Quantity of a Cupful, a little Sugar is to be mix'd with it, and it is to be drank immediately. After this, as much more Water is to be put into the Pot upon the Remainder, and to be boiled as before, to extract all the Juice and what remains of the ſpirituous Part of the Root. Theſe two Doſes are to be taken, one in the Morning, and the other at Night.

The Places where this Root grows are between the thirty-ninth and forty-ſeventh Degree of Northern Latitude, and between the tenth and twentieth Degree of Eaſtern Longitude, reckoning from the Meridian of *Pekin*. There is there a long Tract of Mountains, which the thick Foreſts, that cover and encompaſs them, render almoſt unpaſſable. It is upon the Declivities of theſe Mountains and in theſe thick Foreſts, upon the Banks of Torrents or about the Roots of Trees, and amidſt a Thouſand other different ſorts of Plants, that the *Gin-ſeng* is to be found. It is not to be met with in Plains, Vallies, Marſhes, the Bottoms of Rivulets, or in Places too much expoſed and open. If the Foreſt take Fire and be conſumed, this Plant does not appear till two or three Years after: It alſo lies hid from the Sun as much as poſſible; which ſhews that Heat is an Enemy to it. All which makes me believe, that if it is to be found in any other Country in the World, it may be particularly in *Canada*, where the Foreſt and Mountains, according to the relation of thoſe that have lived there, very much reſemble theſe.

The Places where the *Gin-ſeng* grows, are on every Side ſeparated from the Provinces of *Quan-tong* (which in our old Maps is called *Lea-tum*) by a Barrier of wooden Stakes, which incompaſſes this whole Province, and about which Guards continually patroll, to hinder the *Chineſe* from going out and looking after this Root. Yet how vigilant ſoever they are, their Greedineſs after Gain incites the *Chineſe* to lurk about privately in theſe Deſerts, ſometimes to the Number of two or three Thouſand, at the Hazard of loſing their Liberty, and all the Fruit of their Labour, if they are taken either as they go out of, or come into, the Province.

The Emperor having a mind that the *Tartars* ſhould have the Advantage that is to be made of this Plant, rather than the *Chineſe*, gave Orders this preſent Year 1709 to ten Thouſand *Tartars*, to go and gather all that they could of the *Gin-ſeng*, upon Condition that each Perſon ſhould give his Majeſty two Ounces of the beſt, and that the reſt ſhould be paid for according to its Weight in fine Silver. It was computed, that by this Means the Emperor would get this Year about twenty Thouſand *Chineſe* Pounds by it, which would not coſt him above one fourth Part of its Value. We met by Chance with ſome of theſe *Tartars* in the midſt of thoſe frightful Deſerts: And their *Mandarins*, who were not far diſtant out of our Way, came one after another, and offer'd us Oxen for our Subſiſtence, according to the Commands they had received from the Emperor.

This Army of Herbariſts obſerved the following Order. After they had divided a certain Tract of Land among their ſeveral Companies, each Company, to the Number of an Hundred, ſpreads itſelf out in a ſtraight Line to a certain fix'd Place, every Ten of them keeping at a Diſtance from the reſt. Then they ſearched carefully for the Plant, going on leiſurely in the ſame Order; and in this Manner, in a certain Number of Days, they run over the whole Space of Ground appointed them. When the Time is expir'd, the *Mandarins*, who are encamp'd with their Tents in ſuch Places as are proper for the Subſiſtence of their Horſes, ſend to view each Troop, to give them freſh Orders, and to inform themſelves if their Number is compleat. If any one of them is wanting, as it often happens, either by wandering out of the Way, or being devoured by wild Beaſts, they look for him a Day or two, and then return again to their Labour as before.

The poor People ſuffer a great deal in this Expedition. They carry with them neither Tents nor Beds, every one being ſufficiently loaded with his Proviſion, which is only Millet parched in an Oven, upon which he muſt ſubſiſt all the Time of his Journey; ſo that they are conſtrain'd to ſleep under Trees, having only their Branches and Barks, if they can find them, for their Covering. Their *Mandarins* ſend them from time to time ſome Pieces of Beef, or ſuch Game as they happen to take, which they eat very greedily and almoſt raw. In this manner theſe ten thouſand Men paſſed ſix Months of the Year; yet notwithſtanding their Fatigues, continued luſty, and ſeemed to be good Soldiers. The *Tartars*, which were our Guard, did not fare better, having only what remained of an Ox, that was killed every Day, and had firſt ſerved fifty Perſons for their Subſiſtence.

A, ſhows the Root of the Plant; which, when waſh'd, was white and a little rugged and uneven, as the Roots of other Plants generally are. Fig. 56.

B, *C*, *D*, repreſent the Length and Thickneſs of the Stalk; which is ſmooth and pretty round, of a deepiſh red Colour, except near its Beginning at *B*, where it is whiter, by Reaſon of its Nearneſs to the Ground.

D, is a ſort of Knot or Joynt, made by the ſhooting out of four Branches, which all riſe from the ſame Center, and divide from another at equal Diſtances, and at the ſame Height from the Ground. The underſide of the Branch is green, mix'd with white; the upper Part is much like the Stalk, of a deep red, inclining to the Colour of a Mulberry. Theſe two Colours gradually decreaſe and unite together on the ſides in a natural Mixture. Each Branch has five Leaves. It is remarkable, that theſe Branches ſeparate from each other at equal Diſtances, as well in Reſpect of themſelves, as of the Horizon, and make with their Leaves a circular Figure, nearly parallel to the Surface of the Ground.

Tho' I have finiſh'd the Deſign but of half of one of the Leaves at *F*, yet any one may eaſily conceive and perfect the reſt in the ſame Manner. I do not know that ever I ſaw Leaves, ſo large as theſe, that were ſo thin and fine: Their Fibres are very diſtinguiſhable; and on the upper ſide they have ſome ſmall whitiſh Hairs. The Skin between the Fibres riſes a little in the middle above the Level of the Fibres. The Colour of the Leaf is a dark green above, and a ſhining whitiſh green underneath. All the Leaves are ſerrated, or very finely indented on the Edges.

From *D*, the Center of the Branches, there riſes a ſecond Stalk *D E*, which is very ſtraight and ſmooth, and whitiſh from Bottom to Top, bearing a Bunch of round Fruit of a beautiful red Colour. This Bunch was compoſed of twenty-four Berries, two of which are here drawn, marked 9, 9. The red Skin that covers the Berry, is very thin and ſmooth: It contains within it a white ſoftiſh Pulp. As theſe Berries were double (for they are ſometimes found ſingle) each of them had two rough Stones, ſeparated from one another, of the Size and Figure of our common Lentils, excepting that the Stones have not a thin Edge like Lentils, but are almoſt every where of an equal Thickneſs. Each Berry was ſupported by a ſmooth, even, and very fine Sprig, of the Colour of thoſe of our ſmall red Cherries. All theſe Sprigs roſe from the ſame Center, and ſpreading exactly like the Rays of a Sphere, they make the Bunch of Berries, that they bear, of a circular Form. This Fruit is not good to eat. The Stone is like the Stones of other common Fruit; it is hard, and incloſes a Kernel It is always placed upon the ſame Plan or Level with the Sprig that bears the Berry. From whence it is, that the Berry is not round, but a little flat on each ſide. If it be double, there is a kind of Depreſſion or hollow Place in the middle, where the two Parts unite. It has alſo a ſmall Beard at Top, diametrically oppoſite to the Sprig on which it hangs. When the Berry is dry, there remains only a ſhrivel'd Skin that ſticks cloſe to the Stones, and is then of a dark red, or almoſt black Colour.

This Plant dies away, and ſprings again every Year. The Number of its Years may be known by the Number of Stalks it has ſhot forth, of which there always remains ſome Mark; as may be ſeen in the *Figure* by the Letters *b*, *b*, *b*, &c. From whence it appears, that the Root *A* was ſeven Years old, and that the Root *Fig.* 57. was fifteen.

As to the Flower, not having ſeen it, I can give no Deſcription of it. Some ſay that it is white and very ſmall: Others have aſſured me, that this Plant has none, and that no Body ever ſaw it. I rather believe that it is ſo ſmall, and ſo little remarkable, that they never took notice of it: And what confirms me in this Opinion, is, that thoſe that look for the *Gin-ſeng*, having Regard to, and minding only the Root, commonly neglect and throw away all the reſt of the Plant, as of no Uſe.

There are ſome Plants, which beſide the Bunch of Berries I have deſcribed, have alſo one or two Berries like the former, plac'd an Inch or an Inch and a half below the Bunch. And when this happens, they ſay, if any one takes Notice of the Point of the Compaſs that theſe Berries direct to, he can't fail of finding the Plant at ſome Places diſtant that way, or thereabouts. The Colour of the Berries, when the Plant has any, diſtinguiſhes it from all others, and makes it remarkable at firſt Sight: But it ſometimes happens that it bears none, tho' the Root be very old; as that repreſented *Fig.* 57. had no Fruit, tho' it was in its fifteenth Year. Fig. 57.

They having ſowed the Seed in vain, without its producing any Plant, might probably give Occaſion to this Story, which is current among the *Tartars*. They ſay that a Bird eats it as ſoon as it is in the Earth, and not being able to digeſt it, it is putrified in its Stomach, and afterwards ſprings up in the Place, where it is left by the Bird with its Dung. I rather believe that the Stone remains a long Time in the Ground, before it ſhoots out any Root. And this Opinion of mine ſeems the more probable, becauſe there are found ſome Roots, which are not longer, and not ſo big as ones little Finger, tho' they have ſhot forth ſucceſſively, at leaſt ten Stalks in as many different Years.

Tho' the Plant I have here deſcribed had four Branches, yet there are ſome that have but two, others but three, and ſome that have five or ſeven; which laſt are the moſt beautiful: Yet every Branch has always five Leaves, as well as this here figur'd, unleſs the Number has been diminiſh'd by any Accident. The Height of the Plants is proportionable to their Bigneſs and the Number of their Branches. Thoſe that bear no Fruit, are commonly ſmall and very low.

The Root, the larger and more uniform it is, and the fewer ſmall Strings or Fibres it has, is always the better; on which Account, that marked *Fig.* 57. is preferable to the other. I know not for what reaſon the *Chineſe* call it *Gin-ſeng*, which ſignifies *the Repreſentation* or *Form of Man:* Neither I my ſelf, nor others who have ſearched and inquired into it on purpoſe, could ever find it had any Reſemblance to the Signification of its Name; though among other Roots there may now and then be found ſome which by accident have very odd Figures. The *Tartars* with more Reaſon call it *Orhota*, which ſignifies *the chief of Plants.*

It is not true, that this Plant grows in *China*, as Father *Martini* affirms from the Authority of ſome *Chineſe* Books, which make it to grow on the Mountains of *Yong-pinfou* in the Province of *Peking*. They might eaſily be led into this Miſtake, becauſe that is the Place where it firſt arrives when it is brought from *Tartary* into *China*.

Thoſe that gather this Plant, preſerve only the Root, and bury together in ſome certain Place in the Earth, all that they can get of it, in ten or fifteen Days Time. They take Care to waſh it well, and cleanſe it with a Bruſh from all extraneous Matter; then they dip it into ſcalding Water, and prepare it in the Fume of a ſort of yellow Millet, which communicates to it part of its Colour. The Millet is put into a Veſſel with a little Water, and boils over a gentle Fire; the Roots are laid upon ſmall tranſverſe pieces of Wood over the Veſſel, and are thus prepared, being covered with a Linnen-cloth or ſome other Veſſel placed over them. They may alſo be dry'd in the Sun, or by the Fire; but then, though they retain their Virtue well enough, yet they have not that yellow Colour which the *Chineſe* ſo much admire. When the Roots are dry'd, they muſt be kept cloſe in ſome very dry Place; otherwiſe they are in Danger of corrupting, or being eaten by Worms.

[*This Plant* (Gin-ſeng) *grows to the Height of about* 18 *Inches.*]

A new Genus *of* Plants, *of which the* Gin-ſeng *is a* Species. *Communicated by Mr.* Vaillant *to Dr.* W. Sherrard. n. 354. p. 705.

XI. *Araliaſtrum* is a *Genus* of Plants, whoſe *Flower* A* is complete †, regular, polypetalous, and hermaphrodite, ſtanding on the *Ovary* B. The *Ovary*, which is crown'd by a *Calyx* cut into ſeveral Parts, becomes a Berry D, in which are, for the moſt part, two flat Seeds, like a Semicircle, which both together repreſent a ſort of a Heart. Add to this, the Stalk, which is ſingle, ending in an Umbel, of which each Ray bears but one Flower. Above the Middle of the Stalk come out ſeveral *Pedicles*, (as on that of the *Anemone*) on the Extremities of which grow ſeveral Leaves like Rays, or like an open Hand.

---

* *Vid.* ARALIA *Inſt. rei herb.* Tab. 154.

† Complete, *that is to ſay, that has a* Calyx.

The Species *of this* Genus *are*, [1. *Araliaſtrum Quinquefolii folio, majus*, Nin-zin *vocatum D.* Sarrazin. *Gin-ſeng.* Des lettres edifiantes & curieuſes, *Tom.* X. *pag.* 172.

2. *Araliaſtrum Quinquefolii folio, minus.* D. Sarrazin. *Plantula Marilandica, foliis in ſummo caule ternis, quorum unumquodque quinquefariam dividitur, circa margines ſerratis.* N. 36. Raii Hiſt. III. 658.

3. *Araliaſtrum Fragrariæ folio, minus.* D. Vaillant. *Naſturtium Marianum Anemones ſylvaticæ foliis, enneaphyllon, floribus exiguis.* Pluk. Mantiſſ. 135. Tab. 435. Fig. 7.

To ſhew wherein *Araliaſtrum* differs from *Aralia*, (from whence it takes its Name) 'tis convenient to give alſo the Character of this laſt *Genus*, ſuch as Mr. *Vaillant* eſtabliſh'd it, in his Demonſtrations of the Year 1717.

Aralia * is altogether like the *Araliaſtrum*, as to the Structure and Situation of its Flower, but its Berry conſiſts of five Seeds plac'd round an *Axis.* Moreover its Leaves are branched, almoſt like thoſe of *Angelica*; and its Stalks (which in ſome *Species* are naked, and in others have Leaves ſet alternately) bear each ſeveral Umbels at their Top, in the Form of a Bunch of Grapes.

The Species *of* Aralia *are*, [1. *Aralia caule aphyllo, radice repente.* D. Sarrazin *Chriſtophoriana Virginiana Zarzæ radicibus ſurculoſis & fungoſis, Sarſaparilla noſtratibus dicta.* Pluk. Almag. 98. Tab. 238. Fig. 5. *Zarſaparilla Virginienſibus noſtratibus dicta, lobatis umbelliferæ foliis, Americana.* Ejuſd. Almag. 396.

2. *Aralia caule folioſo lævi*, D. Sarrazin. *Aralia Canadenſis.* Inſt. rei Herb. 300.

3. *Aralia caule folioſo & hiſpido*, D. Sarrazin.

4. *Aralia arboreſcens ſpinoſa*, D. Vaillant. *Angelica arboreſcens, ſpinoſa, ſeu Arbor Indica, Fraxini folio, cortice ſpinoſo*, Raii Hiſt. II. 1798. *Chriſtophoriana arbor aculeata Virginienſis*, Pluk. Almag. 98. Tab. 20.

All the *Species* of theſe two *Genera*, except the laſt of each of them, are common in *Canada.* The Inhabitants of that Colony, and thoſe of *Virginia*, call the firſt *Species* of *Aralia* by the Name of *Sarſaparilla*, becauſe its Roots have almoſt the ſame Figure and Virtues.

Mr. *Sarrazin* writes, that he had a Patient who had been cured of an *Anaſarca*, about two Years before, by the Uſe of a Drink made of theſe Roots; and aſſures us, that the Roots of the ſecond *Species*, well boil'd and apply'd by way of *Cataplaſm*, are very excellent for the curing of old Ulcers; as alſo the Decoction of them, with which they bathe and ſyringe the Wounds. He does not at all doubt, but the Virtues of the third *Species* (which I ſhall briefly deſcribe) are the ſame with thoſe of the ſecond.

---

* *Vid. Inſt. rei Herb.* 300. Tab. 154.

Its Roots creep, and ſend forth Stalks, which riſe commonly to the Height of a Foot and half, and ſometimes to two Feet; the bottom part of them is rough, with reddiſh, ſtiff, and prickling Hairs. Theſe Stalks are ſet from the Bottom to almoſt the Top (which are divided ſucceſſively into ſeveral naked Branches charg'd with Umbels) with branch'd alternate Leaves, almoſt like thoſe of *Podagraria hirſuta Angelicæ folio & odore* D. Vaillant; which Plant is grav'd in the ſecond Tome of *Boccone's Muſæum*, by the Name of *Cerefolium rugoſo Angelicæ folio, Aromaticum*, Tab. 19. and in *Rivini* by that of *Myrrhis folio Podagrariæ.*

XII. Monſieur *Marchand* acquainted the Aſſembly of the *Academy* of *Sciences* in *France*, with the Diſcovery of a new *Simple*. The firſt that brought it into Reputation, was a *Portugueze Surgeon*, who having lived many Years in *Brazil*, diſcovered the Virtues of this Plant; after returning into *Portugal* with a Deſign to raiſe a great Trade with it, he ſent ſeveral *Specimens* of it every where. He called the Plant *Iquetaia*, and attributed to it no leſs Virtues than the Cure of *Apoplexies*, *Pleuriſies*, and *Intermitting Fevers*. He added one Thing, which though more particular, yet ſeemed more probable, which was, that the Leaves infus'd with *Senna*, took from it its diſagreeable Taſte and Smell, without altering any Thing of its *Purgative* Quality. The *Samples* that he ſent, were not in ſufficient Quantity to make Experiment on the Diſtempers, he ſaid it was proper for; but there was enough to try, whether they had the Virtue to correct the Taſte and Smell of *Senna*. Therefore there was infus'd two *Drachms* of it, with as much *Senna* in a *Chopine* of Water, and the Experiment confirm'd the Matter of Fact: Being deſirous to know what *Species* of Plant it was, and it being impoſſible to diſcover it by the Leaves, which the *Portugueſe Surgeon* had taken ſo much Care to cut very ſmall, Monſieur *Homberg*, who had ſome of it ſent him, perceived ſome Seeds ſwimming on the Water, in which they were infus'd; and taking up as many as he could of theſe Seeds, gave them to Monſieur *Marchand*, who ſowed them; from whence grew up a Plant, which we need not go to *Brazil* to ſeek, it grows in *Europe*; nor need we go out of *France* to find it; nay, we may have it all round *Paris*; 'tis the *Scrophularia aquatica*. To be the more certain of it, there was ſome of our *Scrophularia* ſowed on a Bed, and ſome of the other Seed on another, and there was obſerved but ſome ſmall Differences, which may be well attributed to the different Culture and Soil. There was likewiſe try'd the Virtue of our *Scrophularia*, and it was found to have the ſame Effect, in taking away the Taſte and Smell of *Senna*. Monſieur *Marchand* concluded from this Diſcovery, that it was more fit to labour to know the Remedies that are in our own Land, than to run over all the Earth in queſt of that, with much Labour and Charge, which we may have for nothing at Home, if we took the Pains to ſearch: And added, that a knowing *Botaniſt* (meaning his Father) after many long Travels

Of a New Plant *call'd* Iquetaia, *the ſame with* Scrophularia Aquatica, *by Monſ.* Marchand. n. 273. p. 1103.

Travels avowed, that there might be found in all Countries Remedies for all Diſeaſes, and that having apply'd himſelf to this Matter, he had diſcovered a good Number of Simples commonly to be found, that had great Virtues, of which he had graved the Plants. He named among others, the *Achillea Montana Penæ*, which ſmoaked in a Pipe as *Tobacco*, conſiderably eaſes an *Aſthma*.

Of the Attmella *and its* Lithontriptic *Virtue, by Dr.* P Honton. n. 263. p. 790.

XIII. *Attmella*, *Acemella*, and *Hacmella*, for the Seeds are ſo named which were ſent to me in the Year 1691 from the Iſland *Ceylon*, where this Plant grows and is very well known.

The Plant itſelf, which I reared in the Year 1692, bears Flowers on the Tops of the Stalks, compoſed of ſeveral ſmaller tubulous Flowers collected together, and forming a kind of Head, ſupported by a ſix-leaved or many-leaved Calix, very much reſembling the wing-ſtalked *Curaſſa* Marigold, with the Orange Flower (of which there is a Figure in *Pluknet*'s Phytog. in *Herman*'s Par. Batavo, in the Horto Monſpel. *Magnol.* and the Flora Noribergenſi of *Volkamer*) but ſomewhat yellow. After the Flowers are ſhaken, the Seeds follow, which are of a greyiſh brown Colour, long, flat, with a double Beard at Top, to which the Flowers were contiguous. It grows up in ſquare Stalks covered with conjoined Leaves, longer and more prickly than thoſe of the Nettle or Dead-nettle; whence it is conjectured that this Plant is doubtleſs of the Thiſtle or Artichoke Tribe, and of the ſame Species with that called *Bidens* by *Cæſalpinus*, and after him by *Tournefort*, from its forked Seed. Wherefore ſince this Plant hitherto has no Name, I think from the Nature of the Plant the following may be given it.

Bidens Urticæ folio Lithontriptica *Zeylanica*, or the Lithontriptic Nettle-leav'd *Bidens* of *Zeylan*. For amongſt all the Medicines which have been uſed for diſſolving the *Calculus*, this Plant of late Years is become the moſt celebrated, both amongſt our Countrymen living in that Iſland, and very lately it is likewiſe become very famous amongſt ourſelves.

A Soldier, who in the Year 1690 firſt gave an Account of this Herb to our *Eaſt-India* Company, declared that he had cured upwards of a hundred Perſons of the Stone and Nephritick Complaints. And the Governor and chief Council of the *Dutch* in the Iſland of *Ceylon*, teſtify in Letters wrote that ſame Year, its Succeſs on two Perſons who were troubled with the Stone; for they ſay that theſe Perſons voided a great deal of Sand, and broken Pieces of Stone, almoſt without any Pain.

Colombo, chief Surgeon to the Hoſpital in the above Iſland, in Letters which he wrote to me in the Year 1699, in order to confirm the Truth of the above, ſays, that he is poſitive there is no Medicine that has hitherto been found more effectual againſt the Stone and Nephritick Diſorders; and he farther adds, that with very great Pains he had found out three Species of it. The firſt of theſe is covered with light green Leaves, and its Seed is of a dirty yellow Colour. The ſecond has

Plate 19th
of Cart

Leaves of a deep green Caſt, and its Seed is of the ſame Colour with the other. The Seed of the third is black, and the Leaves are a great deal larger than thoſe of the other two, which he ſays are the beſt. He adds, that this Plant is extremely fertile, each producing upwards of ten thouſand Seeds.

They make uſe both of the Leaves of this Plant and the Seeds, which *Colombo* praiſes above all the reſt of the Plant; as alſo of the Root, Stalks and Branches.

The Leaves being gathered before the Flowers puſh out, dried in the Shade, and reduced to a Powder, are given in a proper Vehicle, or infuſed in hot Water, and drank in the ſame manner as Tea. They are likewiſe infuſed in Spirit of Wine, and a Spirit is diſtilled from the Root, Stalks and Branches.

Another Governor of the Hoſpital at *Ceylon* aſſerts, that he had uſed the Flowers, Roots, Extract and Salt with good Succeſs in the *Pleuriſy*, *Colick* and *Fevers*.

Another Plant.

Mr. *Colombo* in his Letters commends likewiſe for their Lithontriptic Quality, the Bark of the Roots, and the Roots themſelves, of a certain Herb, called by the People of *Ceylon*, *Mangul Caranda Pottu*; but what Kind of Herb this is, I know not.

Of the Jeſuit's Bark, *by Dr.* W. Oliver. n. 290. p. 1596.

XIV. *Peru Bark* comes from a Tree of about the Bigneſs of a Plumb Tree, with Leaves like Ivy, but not quite ſo big, and are always green. The *Indians* call it *Querango*. It is gather'd in Autumn, and the Rind taken off all round, as well from the Trunk as Boughs, which grows again in four Months, as *Cork* does: The Trunk is about the Bigneſs of a *Man's Thigh*; it bears a Fruit not unlike a *Cheſnut*, (except in its outer Rind or Shell) which is properly called *China China*, and is eſteem'd by the Natives beyond the Bark taken from the Trunk or Boughs. This Account I received from an ingenious Apothecary at *Cadiz* in *Spain*, *A.D.* 1694, who had liv'd in *Peru*, and had ſeen it growing, and gather'd it ſeveral Times. From this Hiſtory I made this Obſervation, that probably *China China*, or the Rind of the Fruit, was firſt only in Uſe, and the more powerful Medicine uſed in ſmaller Quantities, and that the Bark of the Tree came not into Uſe, till ſome Time after; when the Virtues of it known in *Europe*, occaſioned a greater Demand for it.

A new Kind of Walnut-Tree, *&c. by Mr.* Reneaume. n. 273. p. 908.

XV. Of the *Walnut-Tree* Authors ſeem to have known but ſix *Species*, tho' I can reckon nine. They confounded (unleſs I am deceived) with the *common ſort*, that which the Country People call *Noix Angleuſes*, which one may call *Nux Juglans putamine duriſſimo*, which appears to me to be that which in *Hermolaus*, and in the *Hiſtoria Lugdunenſis* is called *Moratiæ Moracillæ*, and which *Cæſalpin* calls *Surdæ*.

I don't ſee that the ſame Authors have diſtinguiſh'd another Species, which might be call'd *Nux Juglans fructu præcoci*, becauſe they are ſooner ripe than the others, and eaten about the Feaſt of St. *John en Cerneaux*, which has given them, amongſt the Country People, the Name of *Noix Joanneties.* As for that Species I am to treat upon, I can't find any Author that knew of it, and therefore I ſhall call it *Nux Juglans, folio eleganter diſſecto*, or *Acanthi-folia.*

The Oil which is preſſed out of the Walnut-Tree, in certain Provinces is uſed inſtead of Butter and Oil-Olive. In *Berry*, where they have very good Wool, and where they trade very much in Cattle, they have yet but very little Butter; and that little which they have, is worth nothing, and is very dear; ſo that they uſe Nut-Oil in dreſſing their Meat to eat. For this Reaſon there are an infinite Number of Walnut-Trees planted in the middle of the plough'd Lands, in ſuch ſort, that afar off one would take theſe Lands for Woods of Walnut-Trees.

The Want of theſe Trees in this Country obliges the Inhabitants to cultivate them, and they take care to nouriſh them in particular Places, as in a ſort of Nurſery, in order to plant them afreſh when they die, whether it be of Age (which is rare) or whether they decay, or that they are fell'd, for the Wood to work with.

The laſt *Autumn*, two Leagues from *Selles* in *Berry*, in the Pariſh of *Lis*, as I walked in an Orchard, looking upon ſome Plants near a Place where they bred up a vaſt Number of young Walnut-Trees, I perceiv'd in the middle a ſort of Leaf, (or Foliage) which I had never taken Notice of before. I went thither forthwith, and having examin'd it, as I knew not the Subſtance of this Leaf, I taſted it. The Taſte, Smell, Wood and Figure of the Tree, perſuaded me to believe that it was a Walnut-Tree, and I concluded that this was one, tho' I did not remember that I had ever read, or heard of any ſort like this.

This Tree is very young, and did never yet bear any Fruit, perhaps, becauſe it may be *(in a manner)* choak'd up, and that there is neither Air nor Nouriſhment enough, by reaſon of the great Number of other Walnut-Trees, which grow round about it. It is near ſix Feet high, and two Inches Diameter at the Bottom. 'Tis adorned at the Top with many Branches, and (as the Country People ſaid) was about eight or nine Years old, and that they had always found its Leaves like thoſe which I ſaw.

The *(common)* Walnut-Tree bears its Leaves by Pairs, upon a Stalk, which terminates with a like Leaf, that is ordinarily bigger than the reſt: And it has very ſeldom above three Pairs upon each Stalk.

This has ſometimes four or five Pairs, and ſometimes more, which are one while oppoſite, another while alternate, altho' its Leaves appear ſmaller than thoſe of the common Walnut-Tree, becauſe of the Cuttings or *Slaſhes.* They are neverthel[e]ſs as big, if one minds their Circumference taken from the Extremities of theſe *Slaſhes.*

The firſt Pair, and ſometimes the ſecond, are leſs *cut* than the reſt, being ſo only upon the Circumference: but the others are cut ſo deep, that it looks as if the Nerve in the middle of the Leaf was only a Stalk;

and the *Cuts* of the Leaves are ſometimes by Pairs, ſometimes ſingle on one ſide. Theſe Leaves are ſometimes forked at the End, and ſometimes end with a Point. There are alſo ſome Places, where it looks as if the Leaf was torn on purpoſe, almoſt like the *Angelica Canadenſis, foliis quaſi præmorſis.* There are others, where it ſeems that they are double, as if the Stalk or the Nerve was winged, juſt as the winged Stems, or Trunks, or *Caules alati.* All theſe Cuts and Slaſhes are not like Indentures or Notches, but finiſh with a Round. And notwithſtanding all theſe Irregularities, they look ſo pretty, that I can't compare them better *(to any thing)* than thoſe wrought Leaves, which ſerve for Ornaments to the Painters, almoſt like thoſe which adorn the Capital of *(Columns of)* the *Corinthian* Order, or that which in Heraldry they call *the Mantles*, or that which the Botaniſts term *Acanthus* or *Branca Urſina*, which is the firſt Original of this ſort of Ornament.

Dalechamp has obſerv'd an Aereal Honey of a yellowiſh Colour upon the Leaves of a Walnut-tree, during the greateſt Heats of the Summer; which can be nothing but an Effect of the Tranſpiration of this Tree, as of all other Trees, wherein the ſame thing is to be found; as I prov'd in a Diſcourſe to the *Academy* laſt Year, in ſpeaking of the *Sycamore*.

XV. *Papers Omitted.*

1. An Account of Mr. *Sam. Brown*'s (a Phyſician at *Fort St. George*) *Third* Book of *Eaſt-India* Plants, with their Names, Virtues, Deſcriptions, *&c.* by Mr. *J. Petiver.* *n.* 271. *p.* 843.

2. An Account of the *Fourth* Book of the ſame. *n.* 274. *p.* 927.

3. ——— of the *Fifth* Book. *n.* 276. *p.* 1007.

4. ——— of the *Sixth* Book. *n.* 277. *p.* 1055.

5. ——— of the *Seventh* Book. *n.* 282. *p.* 1251.

6. ——— of the *Eighth* Book. *n.* 299. *p.* 1952.

7. *G. J. Camelli* de *Plantis Philippenſibus Scandentibus Tractatus*, ſent to Mr. *Petiver.* To which is added, a *Catalogue* of *Herbs* he formerly ſent him, the *Deſigns* of which are *deſcribed* by Mr. *J. Ray* in the *Appendix* to his *Third* Volume of *Plants.* *n.* 293. *p.* 1707.

8. *G. J. Camelli* de Plantis *Philippenſibus* Scandentibus, Pars *Secunda.* *n.* 294. *p.* 1763.

9. ——— Pars *Tertia.* *n.* 295. *p.* 1809.

10. ——— Pars *Quarta.* *n.* 296. *p.* 1816.

11. An Account of ſeveral Rare *Plants* lately obſerved in ſeveral curious Gardens about *London*, and particularly the *Company* of *Apothecaries* Phyſic Garden at *Chelſea*, by Mr. *J. Petiver*, in Seven Tracts.
n. 332. *p.* 375.
n. 333. *p.* 416.
n. 337. *p.* 33, 177.
n. 343. *p.* 229.
n. 344. *p.* 269.
n. 346. *p.* 353.

XVI. *Accounts of Books Omitted.*

n.210.p.2442. 1. The whole *Art* of *Huſbandry*, by *John Mortimer*, Eſq; 8*vo.*

n.285.p.1411. 2. *Gazophylacii Naturæ & Artis* Decas. In quâ *Animalia* Quadrupeda, Aves, Piſces, Reptilia, Inſecta, Vegetabilia; item *Foſſilia*, Corpora marina, & Stirpes Minerales, è Terrâ eruta; *Lapides* figura inſignes, &c. *Deſcriptionibus* brevibus & *Iconibus* illuſtrantur. Hiſce annexa eſt Supellex *Antiquaria*, Numiſmata, Gemmæ exciſæ & Sculpturæ, Opera *Figulina*, Lucernæ, Urnæ, Inſtrumenta varia, Inſcriptiones, Buſta, reliquaq; ad Rem *Priſcam* ſpectantia; item Machinæ, Effigies clarorum *Virorum*, omniaq; Arte producta. A *Jacobo Petiver*, R. S. S.

n.331.p.344. 3. *Gazophylacii Naturæ & Artis*, &c. Vol. I. in V. Decadibus, per *J. Petiver.*

n.306.p.2253. 4. *Samuelis Dale*, *Pharmacologiæ* ſive *Manuductionis* ad Materiam Medicam *Supplementum*; Medicamenta *Officinalia* complectens: Ut & Notas *Generum* Characteriſticas, *Specierum* Synonyma, Differentias, & Vires. Cum duplici Indice, generali Altero nominum & ſynonymorum præcipuorum; Altero Anglico-Latino, in Gratiam Tyronum. 12*mo*. *Lond.* 1705.

n.325.p.35. 5. Index *Plantarum* Horti *Lugduno-Batavi*, per *Hermannum Boerhaven.* Lugd. Bat. 1710. 8*vo.*

n.345.p.350. 6. *Ludovici Ferdinandi Marſilii* Diſſertatio de *Generatione Fungorum.* Romæ 1710. 8*vo.*

A GENE-

A GENERAL

INDEX

OF ALL

The MATTERS contain'd in theſe Two Volumes.

Note, The *Numeral Letters* diſtinguiſh the *Volumes*, ii *ſignifies* the *Second Part* in each Volume, and the ſmall *Figures* ſignify the *Pages*.

A.

ACOUSTIC Experiments, *Vol.* IV. *Page* 396.

Acres, how many in *England*. IV. 449.

Age, of the Age of MSS. Authors, &c. V. ii. 1.

The Great *Age* of Old *Bayles*, V. 344. of ſeveral Perſons in *Shropſhire*, V. ii. 112. in *Yorkſhire*, 115. in *New-England*, 165. The Menſes till 70 Years of *Age*, V. 352. A new Sett of Teeth after 80 Years of *Age*, V. 353. The *Age* of the World to be found by the Encreaſe of the Saltneſs of the Sea, V. ii. 216.

Agriculture of the *Chineſe*, V. ii. 175.

Air, Experiments ſhewing how much the Reſiſtance of the *Air* retards Falling Bodies, IV. ii. 175, 178.

To Eſtimate the Motion of the *Air* flowing out of the Lungs in Expiration, IV. 441.

The Human *Allantois* diſcover'd, V. 309.

An *Altar* to *Hercules*, V. ii. 47.

Amber, of its Luminous Quality, IV. ii. 275. A Treatiſe on it, 279.

Amulets, V. ii. 123.

A Courſe of *Anatomy*, V. 184.

Anderida, where ſituated, V. ii. 77.

Animals, of Carnivorous *Animals*, V. 1, to 9. A new Claſs of *Animals*, 177.

Animalcules in the *Itch*, V. 197.

Aneuriſma, two Caſes of it, V. 334, 335.

Of the *Ant-bear*, V. ii. 180.

Antiquities, vid. *Roman*.

Antiquities in *Northumberland*, V. ii. 57. *French* and *Iriſh*, 57. in *Ireland*, 125.

Antient Braſs Inſtruments, V. 98 to 108.

Antient Trumpets, 109.

Approximation, the Method of *Approximating*, in Extracting the Roots of Equations in Numbers, improv'd, IV. 80.

A particular *Apoplectic* Caſe, V. 210.

Artaliſtrum, a new Genus of Plants, IV. ii. 319.

Arſenic, of its Preparation, V. 420.

Arteries and Veins, Tables of them explain'd, V. 328. Spermatic, 329. *Oſſifications* of the *Arteries*, 341, 344.

Aſbeſtus, and the incombuſtible Cloth made of it, IV. ii. 282. *Aſbeſtus* found in *Scotland*, 283, 285.

An *Aſthmatic* diſſected, V. 220.

Aſtronomical Obſervations for 1711, 1712 at *Greenwich*, IV. 281. for 1713, 291. A Collection of *Aſtronomical* Obſervations for 1717, 1718, IV. 329. for 1719, 336. *Aſtronomical* Matters in *New-England*, V. ii. 161.

Attraction, a Defence of it, V. 428. The Laws of it, IV. 353.

Attmella, a Lithontriptic Plant from *Ceilan*, IV. ii. 322.

Auroræ Boreales, IV. ii. 134, 135, 153, 154, 163, 168.

A General INDEX.

B.

Barometer, of Dr. *Hook*'s Marine *Barometer*, IV. ii. 4. *Barometrical* Experiments in *Switzerland*, 16. *Barometrical* Altitudes at *Townly*, *Upminſter*, and *Zurich*, 62. 66, 67, 77. The Cauſe of the Variation of the *Barometer*, 19.

Baroſcope, a New one, IV. ii. 6. Obſervations made with it, 9.

The Jeſuits *Bark*, an Account of it, IV. ii. 323.

Bramines, *Indian*, an Account of their Opinions and Worſhip, V. ii. 165.

Tycho *Brahe*'s Caſtle, V. ii. 132.

A Triple *Bladder*, V. 284.

Beads of the Druids, V. ii. 121.

Tumours in the *Breaſt*, V. 216, 218.

Beaſts, V. ii. 146, 156. in *Wales*, 116, 118.

Bellini, ſome Account of him, V. ii. 137.

Birds, Migration of them, V. 33. *Birds* in *Yorkſhire*, V. ii. 117. in *New-England*, 160. Strange ones in *Wales*, V. 33.

Births, the Regularity of them in both Sexes, V. ii. 240.

Blood, to eſtimate its Motion, IV. 441, 445. Its ſpecific Gravity, V. 320. The Circulation of the *Blood* ſeen in the Omentum of a Cat, 329, 330. in Tadpoles, 331. The *Blood-Veſſels* of the Lungs of a Frog injected, and view'd with a Microſcope, V. 227. Pleuritic *Blood* view'd with a Microſcope, IV. 204. A ſtrange Eruption of *Blood*, V. 349. A Periodical Evacuation of it at the Thumb, 351. White *Blood*, ibid.

Bones, ſtrange ones dug up near *Canterbury*, IV. ii. 222, 227, 233. near *Colcheſter*, 245. in *New-England*, V. ii. 159. Human *Bones* of an extraordinary Size near *St. Albans*, V. 387.

On the Fracture of the Neck of the Thigh-*Bone*, V. 388. The Loſs of *Bones* ſupplied by a Callus, 387.

Burning-Glaſs, Experiments on Metals with the D. of *Orleans*'s, IV. 190. with M. *Villette*'s, 198.

C.

Calenture, a Hiſtory of one, V. 364.

California, a Paſſage by Land to it, and ſome Account of it, V. ii. 191.

Callus's ſupplying the Loſs of Bones, V. 387.

Canary-Seed, how cultivated, IV. ii. 309.

Cancer, a ſtrange one, V. 214.

Cantharides, of their internal Uſe, V. 405.

Cape of *Good Hope*, an Account of it, V. ii. 153.

Cartria, where ſituated, V. ii. 83.

Catuvillauni, V. ii. 42.

A *Chalybeat* Water at *Canterbury*, IV. ii. 197.

Chances, a Problem in them ſolv'd, V. ii. 255.

Characters unknown at *Cannara* in *Salſet*, V. ii. 60. in *Wales*, 120. in *New-England*, 165.

The *Center* of Oſcillation, IV. 380.

Of the Laws of the *Centripetal* Forces, &c. IV. 359, 367.

Ceilan, ſome Account of it, V. ii. 176, to 180.

Cinnamon Trees in *Ceilan*, V. ii 180.

A *Child* crying in the Womb, V. 305. A *Child* born full of the Small-Pox, 308. An Emaciated one diſſected, V. 270.

Coal-mines, of the Strata in them, IV. ii. 260.

A *Collier* blown up, IV. ii. 266.

Coins, vid. *Roman*.

Coins, &c. found under Ground in *Lincolnſhire*, IV. ii. 246, 248.

Coins, *Welſh*, V. ii. 121. *Norman* at *York*, V. ii. 30. *Swediſh*, *ibid.*

Pewter Money *Coin'd* by the late K. *James* in *Ireland*, V. ii. 31.

Coffin, a Leaden one found in a *Roman* Burial Place, V. ii. 41.

Cobalt, V. 420.

Cold Diſſolutions and Fermentations, V. 421.

Colic, an unuſual one, V. 264. An extraordinary Effect of the *Colic*, 266.

Colours, and Light, Experiments on them, IV. 173.

Coſtiveneſs, an extraordinary Caſe of it, V. 269, 270.

Compaſs, of the Invention and Improvements of it, IV. ii. 268.

Computations, the common ones of Intereſt corrected, V. ii. 242.

Combinations, and Alternations improv'd, IV. 60.

Obſervations on the *Comet*, An. 1664. at *Rome*, IV. 339. An. 1680. in *Saxony*, 340. An. 1718. at *Berlin*, 342. A ſmall Teleſcopical *Comet*, 1717. 344.

Conic Sections, ſome Properties of them, IV 3.

Copper Ore, IV. ii. 274.

Clocks, keeping Time with the Sun's Apparent Motion, IV. 394.

Of the *Contagious* Diſeaſe amongſt the *Cows*, An. 1714. V. 48.

Convulſions, of an uncommon kind, V. 296.

Cornea, Inciſions on it, V. 204.

Curves, a new Method of Tangents to them, IV. 7. Quadrature of a *Curve* of the Third Order, IV. 25. Problems of *Curves* reſolv'd, 35, 45.

36, 45, 46. Conſtruction and Meaſure of them, 51. A new way of deſcribing them, 57. The Length of them, 44. The *Curve* a Falling Body would deſcribe, &c 351.

Chuſan in *China*, an Account of it, and of the *Chineſe*, V. ii. 171.

Chryſtal, IV. ii. 274.

The Operations in *Chymiſtry*, to be ſolv'd by *Attraction*, V. 428.

D.

A *Daniſh* Spur, V. ii. 108.

Denmark, Obſervables there, V. ii. 128.

Of the *Death-watch*, V. 26, 28.

A *Deaf* and *Dumb* Perſon recovering his Speech and Hearing after a Fever, V. 357.

Two *Deaf* Perſons underſtanding what is ſaid to them by the Motion of the Lips, V. ii. 219.

Deſcent, the Line of quickeſt *Deſcent*, IV. 351.

Diamonds, their luminous Quality, IV. ii. 275.

The *Differential* Method illuſtrated, IV. 141. Some Hiſtory of that Method, 162, 171.

Diving improv'd, IV. ii. 188.

A *Diſſection* of a Morbid Body, V. 319.

Dropſy, V. 231. A *Dropſical* Body diſſected, 286. A *Dropſical* Caſe, the Gall-Bladder diſtended, 287. *Dropſy* miſtaken for Gravidation, 288. A *Dropſy* of one of the Ovaries, 290.

The *Doſes* of Purging and Vomiting Medicines, V. 394, to 402.

Dura Mater, the Cauſe of its Motion, V. 199. A Bone taken from the Falx of it, 202.

E.

Ear, Obſervations on its Structure, V. 204

An *Earthquake* in the North of *England*, An. 1703, IV. ii. 210. *Earthquakes* in *New-England*, V. ii. 16 .

Eaſter, the Rule for finding it explain'd, IV. ii. 27.

Echo, of its Motion, IV. 413.

Elephant, Anatomy of one, V. 82. The Parts of Generation in a Female, 167. Microſcopical Obſervations on its Skin, *ibid.* The way of taming *Elephants* in *Ceilan*, V. ii. 176.

An *Emaciated* Child diſſected, V. 270.

Strange *Epileptic* Fits, V. 209.

Equations, an univerſal Solution of Cubic and Biquadratic, IV. 66. *Equations* of the 3d, 5th, 7th, 9th, &c. Powers ſolv'd, 77. The Method of Approximating in extracting the Roots of *Equations* in Numbers improv'd, 80. A Series for expreſſing the Root of any Quadratic *Equation*, 87.

Exhalations, nocturnal in the *Indies*, V. ii. 215.

F.

Face, an unuſual Blackneſs in it, V. 196.

Flanders, Curioſities there, V. ii. 134.

Flamingo, the Natural Hiſtory and Deſcription of that Bird, V. 63.

Fracture, of the Neck of the Thigh-Bone, an Obſervation on it, V. 388. A remarkable *Fracture* of the Skull, V. 202.

Fermentations, cold, V. 421.

Fiſh, in *Wales*, V. ii. 115, 118. in *California*, 193. The Way of *Fiſhing* in *Chuſan*, 175. A remarkable Skin of a *Fiſh*'s Stomach, 220.

Ficus Indica, V. ii. 181.

Foſſils, Remarks on them, IV. ii. 264. of *Reculver Cliff*, 265. of *Harwich Cliff*, 264. in *Wales*, V. ii. 119, 120.

Froſt, of the Great one, An. 1708. IV. ii. 113.

Flower, of the Parts, and Uſe of the *Flower* in Plants, IV. ii. 305.

Fœtus, of a Bitch receiving no Nouriſhment at the Mouth, V. 34. Bones of a dead *Fœtus* taken out of a Cow's Uterus, 54. Part of one voided by the Navel, 300. through an Impoſthume in the Groin, 301. Extra-uterine *Fœtus's*, 301.

Fountain, a remarkable one in *Sweden*, IV. ii. 187.

Fowl, a Pin in the Gizard of one, V. 53.

Fluxes, how cur'd in *Scotland*, V. ii. 127.

G.

Gangrene, an Account of a ſtrange one cur'd, V. 388.

Glandulæ Renales, and Uterus in a Puerpera, V. 290.

Gibraltar, the Geography of ſome *Roman* Towns near it, V. ii. 31.

Of *Gin-ſeng*, a *Tartarian* Plant, IV. ii. 314, 319.

Gum Lac, its Luminous Quality, IV. ii. 275.

Gurnard, *yellow*, deſcrib'd, V. 35.

Gut, a Piece of a Dog's *Gut* cut out and cur'd, V. 271.

H.

Hair, a Bunch of *Hair* voided with the Urine, V. 279, 281. Balls of *Hair* taken from the Uterus and Ovaria of Women, 295.

A *Hare* diſſected, V. 196.

Harwich Cliff, an Account of it, IV. ii. 264.

Hæmorrhages uncommon, V. 348. Vid. *Blood.* Of the *Hæmorrhoid* Vein, V. 340.

Hen, a Mountain-*Hen* diſſected, V. 196.

Heat, a Scale of the Degrees of it, IV. ii. 1.

Heart, the Anatomy of the *Heart* of Land-Tortoiſes, V. 74. The left Ventricle of the *Heart* prodigiouſly diſtended, 229. The *Vena Azygos* inſerted into the Right Auricle, *&c.* 231. Of the Force of the *Heart*, 231, to 249.

Head, a Bullet in the *Head* for 30 Years, V. 233.

The *Heſſian* Bellows improv'd, IV. 447.

Holland, Remarkables there, V. ii. 134.

Horace, a Paſſage in that Poet explain'd, IV. 474.

Horn-like Excreſcencies on the Fingers, V. 386.

Hottentots, ſome Account of them, V. ii. 153.

Hydatides, in a Sheep's Kidney, V. 54. in a Tumour in the Neck, 214. voided by Stool, 277. with the Urine, 278.

Hypocauſta, of the Ancients, V. ii. 62.

I.

Imagination, the Force of it, V. ii. 161.

Inſects, in *Spain*, V. 10. in the Barks of Trees, 12.

Inſcriptions, vid. *Roman.*

Inſcriptions, an *Etruſcan* one on *Tages*'s Statue, V. ii. 58. *French* and *Iriſh*, 57.

Indians, ſome Account of their Mechanic Arts and Phyſic, V. ii. 182.

The *Iliac* Paſſion, one that died of it diſſected, V. 268. The *Inteſtines* in the Cavity of the *Thorax*, V. 266. The *Inteſtines* grown Cartilaginous, 268.

Infinite Series's, a Diſcourſe on them, IV. 90, 139.

Intereſt, the common Computations of it corrected, V. ii. 242.

Inundations in *Yorkſhire*, IV. ii. 192. in *Ireland*, 193.

Iquetaia, a new Plant from *Braſil* diſcover'd, IV. ii. 321.

Iron, IV. ii. 274.

Of an *Iſthmus* between *Dover* and *Calais*, IV. ii. 222, to 233.

Italy, Obſervations made there, V. ii. 136, 141.

A New *Iſland* rais'd out of the Sea in the *Archipelago*, V. ii. 196, to 213. An Account of the Sunk *Iſland* in the *Humber* recover'd, IV. ii. 251.

Jupiter, an Occultation of a fix'd Star by *Jupiter*, IV. 304, 318. Emerſions of the Firſt Satellite of *Jupiter*, 1713, at *Rome*, 306. A Tranſit of *Jupiter*'s Fourth Satellite over the Diſk of *Jupiter*, 307. Tables for computing the Eclipſes of *Jupiter*'s Firſt Satellite, 308. *Vid.* Collection of *Aſtronomical* Obſervations, 329, 336.

K.

Kepler's Problem ſolv'd, IV. 208.

Kidney, an Ulcer in it, V. 252.

Knife, of the *Pruſſian* one ſwallow'd by a Man, V. ii. 133.

L.

Lacteals, an Experiment of powder'd Blue paſſing them, V. 254.

Lake, Obſervables in the *Lake Vetter*, in *Sweden*, IV. ii. 183. Of the *Lake Lough-Neagh*, in *Ireland*, 193.

Light and Colours, Experiments on them, IV. 173.

A Glade of *Light* in the Heavens, IV. ii. 133. *Lights* in the Air, *&c.* 139, 151. in the Wakes of Ships in the Sea, V. ii. 213.

Lithoſtrata of the Antients, V. ii. 69.

Logarithms, a new way of computing them, IV. 87. A general Method of making them, 156. A new Method of making them, 160.

Long-Life, Inſtances of, in *Shropſhire*, V. ii. 69. in *New-England*, V. ii. 165.

Longitude, Obſervations of the Occultations of the fix'd Stars by the Moon uſeful for finding it, IV. 298.

The *Longitude* of *Cambridge* in *New-England*, IV. 451. of the *Cape of Good Hope*, ibid. of the *Magellan Streights*, 453. of *Lima* in *Peru*, IV. 339. of the Iſland *Virgo Gorda*, ibid. of *Nuremberg*, ibid.

Lungs, an Apoſtemation of them cur'd, V. 221, 225.

Lyre of the *Greeks* and *Romans*, IV. 474.

M.

Mad Dogs, Caſes of their Bites, V. 366, to 369. of a *Mad* Fox, 369.

Magnetical Experiments, IV. ii. 291, 295. of the Law of the *Magnetical* Attraction, 295, 297. Vid. *Variation.*

Males and Females, of their Equality, V. ii. 240.

Man, whether naturally carnivorous, V. ii. 1, to 9.

The *Mantegar* deſcrib'd, V. 182.

The *Manuring* of Land by *Sea-Shells* in *Ireland*, IV. ii. 298. by *Sea-Sand* in *Devonſhire*, 301.

Manuſcripts, how to judge of the Age of them, V. ii. 1.

A General INDEX.

Of a Phyſic *Manuſcript* at *Florence*, V. ii. 140. MSS. *Welſh*, V. ii. 118.

Manna, in *Italy*, V. ii. 142.

Marble, the way of colouring it, IV. ii. 205. A Quarry of *Marble* in *Ireland*, 206.

Mars, a Tranſit of *Mars* near a fix'd Star, IV. 305. *Vid.* Collection of *Aſtronomical* Obſervations, 329, 336.

The *Maxima* and *Minima* occurring in the Motions of the Heavenly Bodies, IV. 219. The *Maxima* and *Minima* applied to Tangents, IV. 7.

Medical Obſervations in *Scotland*, IV. ii. 127.

The *Menſes* till 70 Years of Age, V. 352.

Meridian, an Inſtrument to find it, IV. 464.

A New way of drawing a *Meridian Line*, IV. 461, 462. The Nautical *Meridian Line* mechanically divided, IV. 456. Of a *Meridian* Line drawn through *France*, IV. 468.

Metals, Experiments on them with a Burning Glaſs, IV. 193.

Meteors, an Account of ſeveral, IV. ii. 131, to 167. A Fiery one in *Jamaica*, IV. ii. 131.

Micrometer, how to uſe it in Solar Obſervations, IV. 230.

A Pocket *Microſcope*, IV. 199. The way of making *Microſcopes*, IV. 203. Remarks on *Microſcopes*, V. ii. 238.

Microſcopical Obſervations, IV. 200. V. ii. 224, to 238.

Mines in *Wales*, V. ii. 119.

Mineral Waters. Vid. *Chalybeat*, *Pyrmont*, *Spaw*.

Monſtrous Calves, V. 34, 35. A *Monſtrous* Birth, V. 304.

Moldineſs, of its ſpeedy Propagation in a *Melon*, IV. ii. 308.

Moon, Eclipſes of the *Moon*, An. 1700. IV. 268. An. 1703. 269, 271. An. 1707. 271, 272. An. 1708. 275. An. 1710. 275. An. 1712. 277. An. 1713. 302. An. 1715. 278. An. 1718. 334. Occultations of fix'd Stars by the *Moon*, uſeful for finding the Longitude, IV. 298. An Occultation of a fix'd Star by the *Moon*, 302. Occultation of *Jupiter* by the *Moon*, 303. Obſervations on the *Moon*, &c. 332, 338.

Of a *Mortification*, V. 337.

A *Moſaic* Work at *Leiceſter*, V. ii. 63. Another in *Suſſex*, ibid.

Moſſes in *Scotland*, IV. ii. 253, 256.

The *Motion* of a ſtretch'd String, IV. 391.

Some Remarks on *Muſicians*, V. ii. 9.

Muſic, its Theory reduced to Arithmetical and Geometrical Proportions, IV. 469.

Muſcles, Obſervations on their Texture, V. 390, 392.

Myopes, how they may uſe Teleſcopes without Eye-Glaſſes, IV. 188.

N.

Natural Hiſtory, Obſervations in *Shropſhire*, V. ii. 112. in *Yorkſhire*, 115. in *Wales*, from 117 to 122. in *Ireland*, 125. in *Scotland*, 123, 127.

New-England, Obſervations made there, V. ii. 159.

Nebulæ, or Lucid Spots amongſt the Fix'd Stars, IV. 224.

The Optic *Nerve* waſted, V. 202.

Nouriſhment, a Woman ſix Days in the Snow without any *Nouriſhment*, V. 358.

O.

Optics, a Sphærico-Catoptric Theorem, IV. 184.

Opium, taken in a large Quantity without procuring Sleep, V. 357.

Opoſſum Male diſſected, V. 169. Obſervations on the *Opoſſum*, V. 177.

Oyſters, large ones in *Ceilan*, V. ii. 181.

P.

Painters, ſome Remarks on them, V. ii. 6.

Palm-Trees, V. ii. 143.

Of the Root *Pareira Brava*, V. 404.

Parhelia, IV. 227.

Partus Cæſareus, its Operation, V. 197.

Pavement, Vid. *Moſaic*.

Planets, of *Caſſini*'s Orbit of them, IV. 206. A Solution of *Kepler*'s Problem, 208. Obſervations on ſome of the Primary *Planets*, IV. 318, 329, 336.

Plants, of the Parts and Uſe of the Flower in *Plants*, IV. ii. 305. A New Genus of *Plants*, IV. ii. 319. Of the Taſtes and Virtues of *Plants* of the Sweet Claſs, V. 406. Coal-*Plants*, V. ii. 121. *Plants* in *Wales*, 122. in *New-England*, 160.

Of the *Plague* at *Cophenhagen*, An. 1711. V. 381.

The *Pediculus Ceti* deſcrib'd, V. 25.

Pewter Money coin'd by the late K. *James* in *Ireland*, V. ii. 31.

Phœnicopter. Vid. *Flamingo*.

Of the New *Philippine* Iſlands, V. ii. 185, 189.

Printing, of its Invention and Improvements, V. ii. 11, to 26.

Points, Mathematical, of their Proportion to one another, IV. 1.

Poiſons, Experiments with *Poiſons* on ſeveral Animals, V. 38.

Potatoes, IV. ii. 299.

A *Polypus* in the *Vena Pulmonalis*, V. 219.

The Structure of the *Vena Pulmonalis*, ibid.

A *Puerpera* diſſected, V. 290, 298.

Purgatives, of their Principles, V. 403.

A *Pyramidal* Appearance in the Heavens, IV. ii. 133.

Pyrmont-Waters, of their Virtues and Qualities, IV. ii. 201.

Q.

The *Quadratures* of Figures, IV. 26.

Quadratrix to the Hyperbola, IV. 37. Vid *Curves*.

R.

Of the *Rain* at *Townley* and *Upminſter*, in 1699, 1700, 1701, 1702, 1703, 1704, IV. ii. 65, 67. at *Upminſter* for 1705, 74. at *Zurich*, *Piſa*, and *Upminſter*, 1707, 1708, 77. at *Upminſter* and *Paris* for 18 Years compar'd, 100.

A Lunar *Rainbow* in *Derbyſhire*, IV. ii. 132.

Rainbows, Marine, V. ii. 215.

Reſiſtance, of a Solid of the leaſt *Reſiſtance*, IV. 346, 348.

Rocks, two ſtrange ones in *New-England*, V. ii. 164, 165.

Roman Antiquities in *Wiltſhire*, V. ii. 31. in *Suſſex*, 63. A Leaden Coffin found in a *Roman* Burying Place, 41. *Roman* Coins in *Yorkſhire*, 32, 34. in *Lincolnſhire*, IV. ii. 260. *Roman* Monuments at *Adell* in *Yorkſhire*, V. ii. 40. A Votive Monument, 35. The Veſtigia of a *Roman* Town at *Adell*, 37. *Roman* Inſcriptions at *York*, proving that the *Ninth Legion* reſided there, 41. *Roman* Inſcriptions in *Yorkſhire*, 44. at *Caerleon*, 43. at *Lancheſter*, 49, 40. A *Roman* Sudatory at *Wroxeter*, V. ii. 61. A Teſſelated Pavement, 63. a Bath, 64. *Roman* Mill-Stones, 38. *Urns*, ibid. *Roman* Camps on the *Downs* in *Suſſex*, 76.

The *Royal*-Oak, an Inſcription on it, V. ii. 114.

S.

Salt, the *Chineſe* Way of making it, V. ii. 175.

Of the *Saltneſs* of the Ocean, V. ii. 216.

Sap, of the Motion of it, IV. ii. 302.

Saturn's Satellites, their Motions rectified, with Obſervations on them, IV. 320. *Caſſini*'s Tables of their Motions corrected, 323. *Vid.* Collection of *Aſtronomical* Obſervations, 329, 336.

A *Scorpion* devour'd by a Rat, V. 43.

Small-Pox, of the Inoculation of it, V. 370, to 379.

Smalt, its Preparation, V. 450.

Rattle-*Snakes* in *New-England*, V. ii. 162.

Spain, of Inſects and Marine Animals there, V. 10.

Spaw-Waters, an Examen of them, IV. ii. 198.

Stars, a new *Star* in *Collo Cygni*, IV. 210, 223. A Hiſtory of the New *Stars* for the laſt 150 Years, IV. 222. *Nebulæ*, or Lucid Spots amongſt the Fix'd *Stars*, 224. The Change of Latitude of ſome of the Fix'd *Stars*, 225. *Vid.* Collection of *Aſtronomical* Obſervations, 329, 336.

Of *Secretions* in an Animal Body, V. 249.

Series's Infinite, IV. 90, 130.

Serpents in *Ceilan*, V. ii. 179.

Sleep, an extraordinary *Sleepy* Perſon, V. 353.

Spleen, Human, of the Glands of it viſible to a naked Eye, V. 252. Two, and Three *Spleens* in one Body, *ibid.*

Shells, Land and River-Shells found under Ground, IV. ii. 270.

Sheep, of Worms found in their Heads, V. 15. *Hydatides* found in a *Sheep*'s Kidney, V. 54.

Of the *Silk* of Spiders, V. 20.

Of *Silk-Worms*, and their Silk, V. 18.

A *Sinking* of the Earth in *Kent*, IV. ii. 243. Part of a Hill *Sinking* down in *Ireland*, 250. The *Sinking* of three Oaks into the Ground in *Norfolk*, 253.

Of the *Sunk* Iſland in the *Humber* recover'd, IV. ii. 251.

Spring, a Burning one in *Shropſhire*, IV. ii. 195.

Switzerland, of the Icy Mountains there, V. ii. 152.

A *Solid* of the leaſt Reſiſtance, IV. 346, 348.

Sound, Experiments on it, IV. 396. The Nature and Properties of *Sound*, 414.

Water-*Spouts*, in the *Downs*, IV. ii. 103. in the *Mediterranean*, *ibid.* in *Yorkſhire*, 106. in *Lancaſhire*, 108.

A *Storm* of Rain at *Denbigh*, IV. ii. 101. Of Hail in *Yorkſhire*, 109.

Of the great *Storm* of Wind, *Nov.* 26. 1703. IV. ii. 109. a ſtrange Effect of it in *Suſſex*, 111. in *Holland*, *ibid.*

Stomach, Iron, Nails, Lead, &c. found in the *Stomach* of an Idiot, V. 273.

A *Stone* voided by *Stool*, which had obſtructed the *Ductus Communis Biliarius*, V. 274.

Of a Ball voided by *Stool*, V. 276.

Two large *Stones* voided by the Urethra, V. 283. A Diſſection of one that died of the

Stone,

Stone, 284. Experiments relating to the Cure of the *Stone* propos'd, 284.

Stones of Fruit, the Miſchief of ſwallowing them, V. 256, to 263.

A Skeleton impreſs'd in *Stone*, IV. ii, 272.

Subterraneous Trees in *Hatfield Chace*, IV. ii. 212, 218. at *Dagenham*, 219. in *Scotland*, 253, 256. at *Reculver Cliff*, 263.

Sugar, of its Virtues, V. 353.

Sun, a New Way to find its Parallax, IV. 213.

Spots in the *Sun*, An. 1703. IV. 228. An. 1704, 231. From 1703, to 1708, 235. From 1708, to 1711, 240. Mr. *Crabtrie*'s Opinion of theſe Spots, 241.

An Eclipſe of the *Sun*, An. 1694. IV. 247. An. 1703, 249. An. 1706, 249, to 254. An. 1708, 255. Of the Total Eclipſe of the *Sun*, April 22. 1715, 255, to 267. An. 1718, 268.

Mock-*Suns*, and Circular Arches, IV. 227.

Suſſex, of the Site of ſome *Roman* Towns there, V. ii. 63.

Skull, a remarkable Fracture of it, V. 202.

Scurvy, a Hiſtory of a very extraordinary one at *Paris*, 1699, V. 359.

Storax liquida, the way of making it, V. 417.

T.

Tangents, a New Method of them, IV. 7.

Taſtes, Obſervations on the Claſs of Sweet *Taſtes* in Plants, V. 406, to 417.

Tea, of three Sorts of it in *China*, V. ii. 174.

Teeth, a New Sett of them after 80 Years of Age, V. 353.

Large *Teeth* (of an Elephant) dug up in *Ireland*, IV. ii. 236, 237, 244. Large *Teeth* and Bones, in *New-England*, V. ii. 150. in *Northumberland*, 47.

Teleſcopes, how they may be us'd by Myopes without Eye-Glaſſes, IV. 188.

Teleſcopic Sights firſt uſed by Mr. *Crabtrie*, IV. 345.

A Pagan *Temple* at *Cannara* in *Salſet*, V. ii. 60.

Teneriffe, a Journey to the Pike, V. ii. 147.

Thermometer, a new one, IV. ii. 10.

Tobacco, how cultivated in *Ceilan*, IV. ii. 314.

Tornadoes, V. ii. 171.

Tortoiſe, the Anatomy of the Heart of a Land-*Tortoiſe*, V. 74.

Tubæ Fallopianæ, impermeable, V. ii. 266.

Tumours, one in the Neck with a bony Subſtance, V. 211. another full of *Hydatides*, 214. A Schirrous one on the Breaſt, 216. Another, 218. A large one on the Thigh, V. 388.

Turnips, of their great and ſpeedy Vegetation, IV. ii. 311.

Thunder, Accidents by *Thunder* and Lightning, IV. ii. 126, to 131. The Direction of Ship-Compaſſes chang'd by *Thunder* and Lightning, V. ii. 163.

Antient *Trumpets* found in *Ireland*, V. ii. 109.

U.

One of the *Ureters* diſtended, V. ii. 266.

Urine, ſeveral ſolid Bodies voided with the *Urine*, V. 281. Of one that liv'd 17 Years without making any *Urine*. V. ii. 115. A Boy who voided *Urine* by the Navel, V. ii. 183. Of a Paſſage for the Drink and *Urine* to the Bladder diſtinct from the Ureters, V. ii. 264.

Urns, &c. in *Ireland*, V. ii. 95. in *Norfolk*, 97.

Uterus, a Diſſection of it, in a *Puerpera*, V. 290. Balls of Hair taken from the *Uterus* and *Ovaria*, 295.

V.

Vacuum, Experiments of Pendulums in *Vacuo*, IV. ii. 168. Gun-powder fir'd in *Vacuo*, IV. ii. 171, 172. The Deſcent of Malt-Duſt in *Vacuo*, 173. Experiments proving an Interſpers'd *Vacuum*, 173.

The Effects of the *Indian Varniſh*, V. 417.

The *Variation* at *Paraiba*, IV. 453. in the *Atlantic* and *Æthiopic* Oceans, 456.

Vegetation, Experiments on it, IV. ii. 310.

Veins and Arteries, Schemes of them explain'd, with ſeveral Anatomical and Chirurgical Obſervations, V. 328.

Venereal Diſeaſe, of its Antiquity, V. 381.

Venus, the Cauſe of its appearing in the Day-time for ſeveral Days together, IV. 300.

Veſuvius, Eruptions of it, An. 1707. IV. ii. 207. An. 1717, 209.

Vetter, Obſervables in the Lake *Vetter* in *Sweden*, IV. ii. 183.

W.

Wales, Obſervations in a Journey through it, V. ii. 117, to 123.

Walnut-Tree, a new Kind, IV. ii. 323.

Water, of the Aſcent of *Water* between two Glaſs Planes, IV. 423. The Cauſe of the Aſcent and Suſpenſion of *Water* in Capillary Tubes, 423. The Action of Glaſs Tubes on *Water* and Quickſilver, 428.

Of the Motion of Running *Waters*, IV. 436.

Water ſtinking, and recovering its Sweetneſs, V. ii. 171.

The *Weather*, in a Voyage to *China*, IV. ii. 18. at *Chuſan* in *China*, IV. ii. 27. at *Oates* in *Eſſex*, 1692. IV. ii. 48. at *Upminſter* in *Eſſex*, for 1699, 1700, 1701, 1702. IV. ii. 62, to 67. at *Upminſter* 1703, 1704. IV. ii 67. at *Upminſter* 1705, IV. ii. 74, to 77. at *Upminſter*, *Zurich* and *Piſa*, 1707, 1708, IV. ii. 77, to 100.

A large *Wen* cut off the Cheek, V. 215.

Witney, a *Roman* Town, V. ii. 99.

Of one that could neither *Write* nor Read, yet cou'd caſt up Sums, V. ii. 219.

Woodpecker, the Structure of its Tongue, V. 55.

Worms, in the Heads of Sheep, V. 15.

World, a Propoſal to find its Age, V. ii. 216.

Wroxeter, a *Roman* Sudatory diſcover'd there, V. ii. 61.

THE END.

This book should be returned to the Library on or before the last date stamped below.

A fine is incurred by retaining it beyond the specified time.

Please return promptly.

~~JAN 21 '65 H~~

~~FEB 15 [illegible]~~

~~445338~~